United States Court of Appeals

for the Second Circuit

APPENDIX

76-7490
76-7514

United States Court of Appeals
For the Second Circuit

UNITED STATES COURT OF APPEALS
FILED
FEB 16 1977
A. DANIEL FUSARO, CLERK
SECOND CIRCUIT

EUTECTIC CORPORATION, NEW METALS CORPORATION and METALLIZING COMPANY OF AMERICA, INC.,

Plaintiffs-Appellees and Cross-Appellants,

v.

METCO, INC.,

Defendant-Appellant and Cross-Appellee.

JOINT APPENDIX

VOLUME V OF EIGHT VOLUMES

(EXHIBITS — Pages E1 to E241)

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The Court is respectfully requested to disregard the underlinings, marginal notations, asterisks and other markings of plaintiffs' counsel appearing on the pages reproduced in the Joint Appendix.

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E 1

Mr. F. J. Glaser 3/11/66 J. F. Quane

A. D. Joseph

Your Memo of 3/5/66 Re: Nickel Aluminide Powders

Nickel aluminide composition referred to attains its usefulness by virtue of a nickel coating around the aluminum--protecting the aluminum transferring across a flame while still allowing an exothermic reaction to occur and hence better bonding. Manufacturer of this material is Sherritt Gordon Mines exclusively for Metco use in the surfacing area as indicated in the Sherritt Gordon Mines letter of February 11, 1965 (copy attached). In addition, Metco holds a patent on the use of this consumable for metal spraying (#3,254,978 - attached).

In anticipation of a requirement for a like or better material, I have acquired nickel coated aluminum - 10 silicon powder from Sherritt Gordon Mines for metal spraying. They agree they can produce it for use outside their agreement with Metco. Mr. Kapralos has indicated it lies outside the Metco patent range. Anticipated use: bonding layer for other metal spray products. Our material may have an advantage over Metco's in that it should be lower melting.

Test evaluation is in progress now by Mr. Tammaro in line with the development of a complete metal spray line; target date October 1. Comparison with the Metco 404 product will be obtained. Deposition of Metco 404 with the Metallizing torch is very poor due to overheating and reaction in the flame. Material was not evaluated in the prototype dual-burning torch.

As an alternative to nickel coated Al-61, I have requested Stark to supply some nickel coated titanium for evaluation. However, this material appears to be covered under the Metco U.S. patent.

One offshoot of this work is interest on our part in a nickel coated cast iron as a synthetic hardenable Metallizing powder. Nickel coating being used to reduce sparking. Material has been ordered.

Cost of Sherritt nickel coating in quantity is $1.50 - $1.00/lb. exclusive of raw material costs.

A. D. Joseph

ADJ:ca
Att. (2)

Def Exh. 154
10/4/73 JF

50138

DEFENDANT'S EXHIBIT A

E 2

SHERRITT GORDON MINES LIMITED

Marketing Division

25 KING ST. WEST, TORONTO 1, CANADA

Telephone 363-9241, Area Code 416 | *Telex 02-2491*

February 11, 1965.

Mr. A. D. Joseph,
Supervisor - Research & Development,
Eutectic Welding Alloys Corporation,
40-40 172nd Street,
Flushing 58, New York.

Dear Dave:

It was a pleasant surprise to find your name at the bottom of your February 5 letter. Only last week we visited your former associates at Pratt and Whitney and learned of your new association. We wish you all the best in your new endeavours.

Under separate cover I am enclosing two papers which outline in some detail the process we have developed for coating a wide range of powdered materials with nickel and cobalt, to produce what we refer to as composite powders.

In brief, we can coat almost anything that does not react with the nickel ammonium sulphate solution that we employ in our hydro-metallurgical reduction process. Operating temperature and pressure during the hydrogen reduction process are 380°F and approximately 500 p.s.i.g. respectively.

We have prepared hundreds of compositions involving the coating of carbides, oxides, nitrides, borides, silicides, and, of course, those metals which do not dissolve or react with the coating solution.

We are attaching for your information copies of our data sheets describing several such composite powders which we offer for sale as standard products. Some of these, notably the cobalt coated tungsten carbide and nickel coated graphite are finding small but growing commercial markets.

2/.....

50139

(2 sheets) 2/11/65 Def. Res. Stn.

Sherritt metallurgical process # 3,254,970

We would like to point out that although we do produce nickel coated aluminum, this material is not available from ourselves for flame or plasma spraying application. For a number of years we have co-operated with Metco Inc., of Westbury, Long Island in the development of nickel aluminum for metallizing application. As a result of this work we have agreed that all sales of our powder should be through Metco who now offer it as a commercial product.

We are certainly prepared to co-operate with you and others in the development of other commerical products prepared by our composite powder process. In our research laboratories we can prepare small batches of composite powders to your specifications for your evaluation. Our charges for this work naturally reflect the high cost of small volume production in our research laboratory. These standard charges are $250.00 per lot of up to four pounds of composite powder coated core material which you would provide. Naturally when production is moved to our special products plant the cost of such larger production is greatly reduced. The prices quoted in our composite powder data sheets are indicative of the level to which such prices could be subsequently lowered.

We appreciate your interest in the possible application of our processes and products and look forward to renewing our personal association with you.

Very best regards.

Yours very truly,

Allan Lee

A. H. Lee,
Assistant Manager,
Market Development.

AHL/sia
Encl.

50140

~~56139~~

E 4

EUTECTIC WELDING ALLOYS CORPORATION
40-40 172ND STREET
FLUSHING 58, NEW YORK

EXECUTIVE OFFICES

FLUSHING 8-4000

April 10, 1968

Mr. John Calimafde
Hopgood and Calimafde
Lincoln Building
60 East 42nd Street
New York, New York 10017

RE: Metco

Dear John:

Enclosed herewith is a copy of Patent 3,322,515 and copies of reports on work done in 1953 on the subject matter of the Patent Claims.

Would you be good enough, to study the enclosed file and advise me as to your opinion of the validity of the Patent Claims. Incidentally, I hope to receive the patents cited against Patent 3,322,515 in the next day or so, and I will send you copies of these shortly.

I have not ordered the file history, and in view of the conglomerate parent applications referred to in the patent, you may wish to have a study made of the file history. I would appreciate receiving your opinion at your earliest convenience.

Very truly yours,

Harry Kapralos

HK:hpc
enc.

50446

DEFENDANT'S EXHIBIT B

Pratt & Whitney Aircraft DIVISION OF UNITED AIRCRAFT CORPORATION UA

E4 - 1

P&WA SPECIFICATION

PWA 1337
REVISION
ISSUED 12/27,
REVISED 68

POWDER, FLAME SPRAY, NICKEL - ALUMINUM
95Ni - 5Al
Nickel - Aluminum Composite Particles

1. ACKNOWLEDGMENT: Vendor shall mention this specification number in all quotations and when acknowledging purchase orders.

2. COMPOSITION: Powder shall consist of an aggregate of aluminum and nickel particles meeting the following composition.

Aluminum	4.0 - 5.5
Impurities, Total*	2.50 max
Nickel	remainder

*If determined; present as volatile phenolic binder.

3. CONDITION: As fabricated.

4. TECHNICAL REQUIREMENTS:

4.1 Particle Size Distribution: Shall be as follows; tests shall be performed in accordance with ASTM B214, insofar as practicable.

	% by wt	
ASTM Sieve	min	max
+140	--	0.5
+170	--	5
-325	--	10
+325	90	--

4.2 Flame Spraying: Powder shall be capable of producing acceptable flame spray coatings. Powder shall react exothermically during deposition.

QUALITY: Powder shall be uniform in quality, condition, and color; it shall be dry and free from foreign materials.

CONTROL: Metallurgical control and control of shipments shall be in accordance with the latest issue of PWA Specification 300.

7 IDENTIFICATION: Each package shall be permanently and legibly marked to give the following information:

POWDER, NICKEL - ALUMINUM
PWA 1337
BATCH OR LOT NUMBER_____
MANUFACTURER'S IDENTIFICATION_____
WEIGHT, AVOIRDUPOIS_____

8. PACKAGING: Powder shall be supplied in sealed containers to protect it against injury or contamination during shipment and under normal dry storage conditions.

9. APPROVAL:

9.1 Powder shall be procured only from sources approved by Pratt & Whitney Aircraft Engineering Department.

Draft's E+17 FOR I.D
MC
9/6/73

Code Ident No. 77445
Furnished Under Contract

G.O. 615 REVISED 8-68

DEFENDANT'S EXHIBIT D

505775

PWA 1337
REVISION

3.2 Vendor shall use the same manufacturing procedures, processes, and methods of inspection for production powder as for approved sample powder. If necessary to make any change, vendor shall obtain written permission from purchaser prior to first shipment incorporating such change.

REJECTIONS: Powder not conforming to this specification or to authorized modifications will be subject to rejection.

50576

Code Ident No. 77445
Furnished Under Contract

REV. 8/68

DX 8

E 5

Translation

CASTOLIN

From : Castolin Vienna

Date: October 9, 1969 Lg

To : Mr. U.Ch. Doenz

Re : Competition / Metco N System

Dear Mr. Doenz,

During the Welding Trade Fair in Essen, we discovered at the stand of Metco company a metal spray gun, which is in principle very similar to our RW-burner. The essential difference, however, of this new METCO "N-System" is, that the process can effectively be performed at very low temperature (100 - 150° C) and is excellent for surfacing of shafts and bearing seats.

The low working temperature permits surfacings in the practice, which do not deform the work piece, and still bonds perfectly well with the base material.

The bonding with the base material is achieved by means of a Al-Ni powder.

On this first layer, according to need, further thicker or thiner layers of different powder alloys can be applied (layed).

It seems to us, that in a very close future, by means of this new process an important competition for our RW and Eutalloy products will have to be faced and we would appreciate it very much, if in a very short time our Research department could obtain a similar powder alloys - mostly Al-Ni alloys.

We hope to have been of service to you with above information and remain,

with best regards,

50344

CASTOLIN GmbH

(Mr. Prucha left for a trip after dictation)

DEFENDANT'S EXHIBIT E

Translation

METCO "N" SYSTEM

METAL SPRAYING RENDERED EASIER

- Metal spraying without compressed air
- Metal spraying without dust
- Metal spraying without pre-knowledge
- Metal spraying without high Investments

What is the process ?

The Metco System type N presents a flame spray process, by which repairs - with a very small investment - of worn and defected workpieces can be done very quickly and economically.

Application modus

The main part of the flame spray apparatus type N, is the gun. Metalpowders are conveyed in it to a flame, were they are melted and sprayed on a roughened surface. The sprayed particles are cooled on the part and freeze to a layer. Since the workpieces are not heated during the spraying process (max. 100°C), this method can be described as "Cold procedure".

Who can apply this process ?

Everywhere, where an urgent repair is concerned, aither in a small workshop or a big industry, the Metco System N type can be applied. The very low equipment and establishment costs are the leading factors of the economical application of this new Metco method.

50345

METAL SPRAYING WITHOUT EXPERIMENTS

E 7
Metco 143

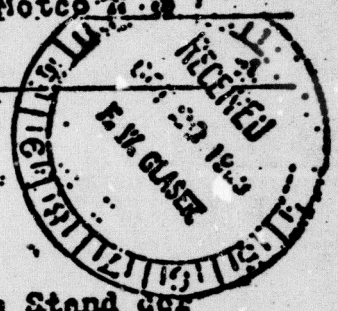
Castolin
Verbindungen bei niedriger Temperatur

INTERNE KORRESPONDENZ

von CASTOLIN WIEN Tag 9. Okt. 1969 Lg

an Hr. U.G. Doenz Betr. Konkurrenz / Metco

Kz



Sehr geehrter Herr Doenz,

in der Schweissfachmesse in Essen entdeckten wir am Stand der Firma Metco eine Metallspritzpistole welche unserem RW-Brenner im Prinzip sehr ähnlich ist. Der wesentliche Unterschied jedoch dieses neuen METCO "M-Systems" besteht darin, daß dieses Verfahren tatsächlich bei ausserordentlich niedrigen Temperaturen (100 - 150°) sich ausgezeichnet für Auftragungen an Vollon und Lagersitzen eignet.

Die tiefe Arbeitstemperatur ermöglicht in der Praxis Auftragungen durchzuführen, welche das Werkstück nicht deformiert, und trotzdem eine ausgezeichnete Bindung mit dem Grundmaterial ergibt.

Die Bindung mit dem Grundmaterial wird mit Hilfe eines Al-Ni-Pulvers erzielt.

Darauf können je nach Bedarf verschiedene andere Pulverlegierungen in mehr oder weniger unbegrenzter Höhe aufgetragen werden.

Uns erscheint, daß aus diesem neuen Verfahren in Kürze eine bedeutende Konkurrenz für unsere Produkte RW und Eutalloy erwachsen wird und deshalb würden wir es sehr begrüßen, wenn wir in absehbarer Zeit von unserer Forschungsabteilung ähnliche Pulverlegierungen - vor allem Al-Ni Legierungen - erhalten würden.

Wir hoffen, Ihnen mit unseren Informationen gedient zu haben.

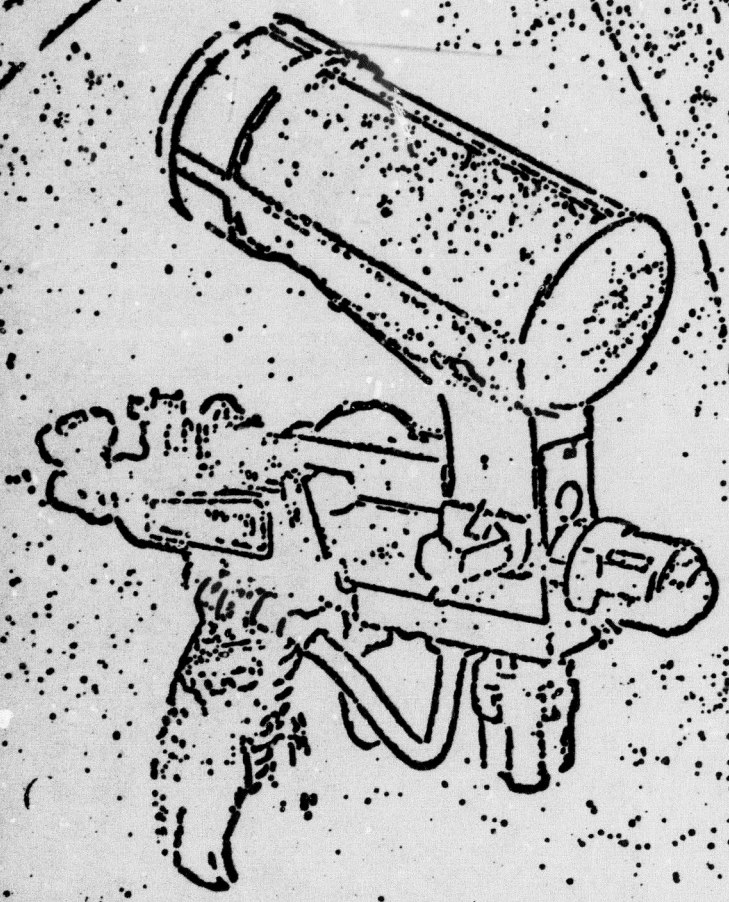
Mit freundlichen Grüßen

CASTOLIN GesmbH

Anlage
Fotokopie der METCO
M Metallspritzpistole

(Hr. Fruehn hat nach Diktat verreist)

50347



METCO

N

SYSTEM

Metallspritzen leicht gemacht

- Metallspritzen ohne Preßluft
- Metallspritzen ohne Staub
- Metallspritzen ohne Vorkenntnisse
- Metallspritzen ohne hohe Investitionen

Was ist das Verfahren?

Das METCO System Typ N stellt ein Flammspritzverfahren dar, bei dem mit nur geringen Investitionskosten Reparaturen an verschlissenen oder fehlbearbeiteten Werkstücken schnell und wirtschaftlich durchgeführt werden können.

Wie wird es angewandt?

Der Hauptbestandteil der Flammspritzausrüstung Typ N besteht aus der Pistole. In ihr werden Metallpulver in eine Flamme gebracht, wo sie angeschmolzen und auf eine vorbereitete Oberfläche gespritzt werden. Die Spritzpartikel kühlen dort ab und erstarren zu einer Schicht. Da die Werkstücke während des Spritzvorganges nicht hochgradig erwärmt werden (max. 100° C), kann man diese Methode als „Kaltverfahren" bezeichnen.

Wer kann das Verfahren einsetzen?

Überall da, wo es um Ausschußrettung oder um Reparaturen von Maschinenteilen geht, sei es in einem kleinen Handwerksbetrieb oder in einem großen Industriewerk, kann das METCO System Typ N eingesetzt werden. Die geringen Anschaffungs- und Betriebskosten sind maßgebend für den wirtschaftlichen Einsatz dieser neuartigen METCO Methode.

50348

Metallspritzen ohne Experimente

E 9

14-10-69

From the Desk of U. Ch. DOENZ

MR. glaser

Frank,
This seems to indicate that Metco is waking up to the fact that our RH process offers a good potential.
What is your opinion re proposed powders (by Metco)?

U. D.

50346

DEFENDANT'S EXHIBIT F

Volume 1 - 9 FOR I.D. E 10

9/6/73

"ROUND TRIP" CORRESPONDENCE SET

TO PERSON RECEIVING THIS COMMUNICATION: WRITE REPLY IN SPACE PROVIDED. SEPARATE FORM SET – RETURN ORIGINAL TO SENDER AND KEEP COPY.

DANIEL IRVING PRESS, N. Y., 10019

ROUND TRIP LETTER

TO Mary Lambros

DATE 10/21/69 SUBJECT Attached from Doenz - Metco N Syst

Please have attached translated ASAP.

SIGNED J. P. Broderick/ms-Att, DEPT.

REPLY

RECEIVED
OCT 22 1969
TECHNICAL SERVICES

DATE SIGNED

DEFENDANT'S EXHIBIT 6

50551

Defts Ex 10 for I.D. E 11
NC
9/6/73

10/24/69 J.F. Quaas

F. W. Glaser
J. P. Broderick
Metco N Gun

This gun has been advertised recently and was developed about a year ago. Essentially, it is a stripped-down Model 2P - modified....

- employs only one nozzle
- gas delivery to the nozzle is through fixed orifices thereby eliminating the expensive wall-mounted flow meters
- powder metering device simplified

They are promoting the gun strictly for "metallizing" - type applications....building up shafts with steel and stainless powders - not nickel-base self-fluxing types. Ni

In order to get these low cost boron-free powders to bond, they first spray with nickel-aluminide. Obviously, since there is no fusing operation, the shaft never gets above a few hundred degrees temperature. ?

The N Gun sells for $480-541 depending upon accessory selection. This is about half the price of the standard guns.

JPD/ms
Att.

50342

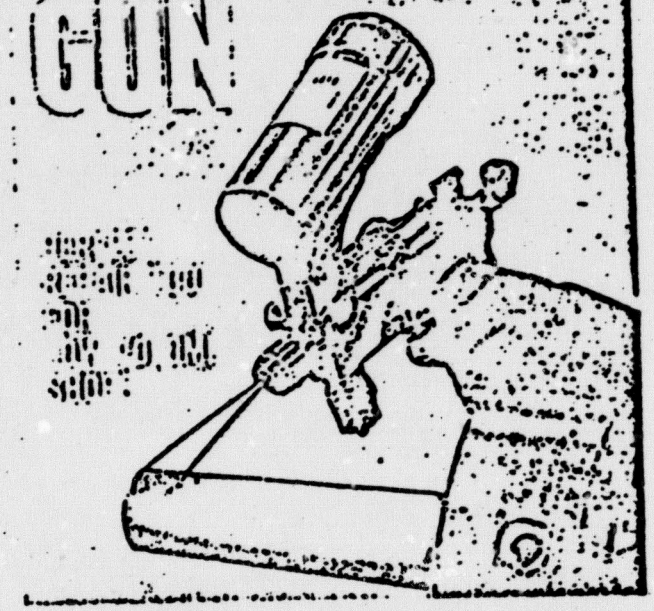
ADMITTED
OCT 1 1973

DEFENDANT'S EXHIBIT H

Dft's Ex 11 FOR ID
MC
9/6/73

DB mdl E 12

NEW LOW-COST METALIZING GUN



REPAIR WORN JOURNALS, PACKING AND SEAL AREAS, PRESS FITS, MISMACHINED PARTS!

The new Metco Type "N" gun rebuilds these parts fast, by spraying on new metal. The cost-cutting "N" was designed for the shop that handles a variety of repairs. It does the job quickly and simply.

Here's how the "N" gun can work for you:

- FAST REPAIR... faster than welding, plating or sleeving.
- LOW COST... original investment is low. Repair costs are far below welding, sleeving, plating or new-part cost.
- SIMPLE... equipment is self-instructing, requires no special skills or techniques. If you can operate a lathe, you can spray with the "N" gun.
- PORTABLE... requires no special accessories. You can set up and spray on any lathe—in minutes.
- COLD PROCESS... rebuilds parts without warpage or distortion.

ACT NOW, find out how the "N" gun can cut your repair time and reduce your repair costs. Write for free information to: METCO Inc., 1119 Prospect Avenue, Westbury, L. I., New York 11590.

METCO METCO INC.

169—Use IR Reader Service Card for Data

50343

DEFENDANT'S EXHIBIT I

E 13

J. Broderick - F. Ulshnia - J. Martens
A. D. Joseph

1/3/70

J. P.

Powders identified as 1-69A and 2-69A are SPRAM prebond powders for comparison to Metco 404.

Material was prepared following the recommendations of the Sr. Vice Presid

ADJ:ea

Defts Ex 14 FOR ID
NS
9/6/72

50163

DEFENDANT'S EXHIBIT
J

E 14
Dft's Ex 16 FOR I.D.
AC
9/6/73

RESEARCH REPORT

CODE NO: Spram PreBond Powders DATE: March 18, 1970

TEST REQUESTED BY: Mr. Quaas TESTED BY: J. Martens

MATERIAL FROM: Mr. Joseph QUANTITY SUBMITTED: 2 samples (approx. 600 gms. ea.)

	SIZE	CORE	COATING
ELECTRODE:			
ROD:			
FLUX:			
OTHER:			

COMPARED TO: Metco 404

TEST RESULTS:

Samples submitted: 1-69A
2-69A

Samples submitted were tested through Spram torch using standard pressures. Metco 404 comparator was run through Metco 5P gun (using vibrator) at recommended flow rate settings. Tests were conducted on 1/6" x 3" x 6" and 1/4" x 2 " x 6" mild steel plates. Base metals were prepared by cleaning in Acetone and also cleaning with coarse emery cloth.

General

The powders both are a coarser sieve than Metco 404 and appear to be heterogeneous mixture of gray-white powders.

No problems were encountered feeding the samples through the Spram torch. Glaring is common for all samples but fuming for both Spram prebond alloys is much less than 404 sample. Sprayed surfaces show coarser, gray appearance than Metco's lt. blue smooth surface. Optimum spray distance was approximately 10-12 inches. Closer tip-to-work distance shows base plates to get oxidized and overheat; further than 12 inches shows very inefficient results with much of the sprayed alloy burning up in the flame and/or missing the plate. Of the two test samples, 69A-2 shows a darker surface than 69A-1 sample. Both appear rougher than 404.

DEFENDANT'S EXHIBIT M

50410

Test Results:

Test samples which were not cleaned with emery showed poor bonding with severe "lift off" noted (particularly at the ends of the plate). Metco 404 alloy showed better bonding on uncleaned plates.

Samples sprayed onto 1/16" x 6" x 3" plates (approx. .010" thick) were subsequently bent through 180°

1. immediately after spraying while plates were warm

2. after plates had been altered to cool for 24 hours

None of the samples (while warm) showed any cracking (incl. 404). Tests after 24 hours of cooling showed cracking for Metco sample. No edge "lift off" noted with any sample on 1/16" plate.

Tests on 1/4" x 3" x 6" mild steel plates consisted of spraying approx. 012" coating of prebond alloy on emery clean base plates. Subsequently, 14494 was sprayed (approx. 020" thick).

As a comparator, Metco 404 was sprayed apprx. .010" thick on emery cleaned mild steel plates. Subsequently, 12C alloy had been sprayed on top of prebond alloy (approx. .020" thick).

Edge "lift off" noted with Spram prebond with 14494. None encountered with Metco 404 with 12C alloy.

NOTE: Insufficient material was received for extensive metallography work on round stock (shafts or pipe).

COMMENTS: Spram prebond alloys show poorer bonding on thick mild steel plates (1/4") than Metco 404.

JM/ms

E 16

INTER-OFFICE CORRESPONDENCE

TO: J. F. Qunas DATE: 3/26/70 CC:

FROM: J. P. Broderick

SUBJECT: Nickel Oxide-Aluminum Powder

Dept's Ex 15 Part D
NE
9/6/73

I attach a test report covering the nickel oxide-aluminum powder samples submitted by Dave Joseph as 1-69A and 2-69A.

This test report covers additional material submitted after it was established that we received insufficient original material for test.

You will note that in order to test the attachment of the spray coating to the sub-strate, material thin enough to bend (1/16") is chosen.

Subsequent testing was conducted on 1/4" plate.

On the whole, the impression we get is one of less bonding when compared to Metco 404.

The whole subject of exothermic powders should be reviewed. Assuming Onders is the key man here (I recently sent him the Model U prototype), it is my recommendation that he be brought into this project. What I am saying simply is that we are not in a position to test materials of this type and that Onders - assuming he has friendly contacts - can help us tremendously.

What I would recommend is the preparation of a series of powders representing so-called exothermic types. These would be:

1. Both Metco grades - sub-contracted.

2. The nickel titanate (Exotherm) from Rose.

3. The prebonded, prereacted nickel aluminide from Rose.

DEFENDANT'S EXHIBIT 5

50169

NC
8/30/73

NICKEL ALUMI

COMPOSITIONS

CONTENT - GRAMS	T60-1	T60-2	T60-3	T60-4	T60-5	T60-6
NICKEL BASE POWDER	400 CCC 131.9	100 CCC 16	80 N.O	400 CCC 253	229 BLACK N.O	80 CCC 15.2
ALUMINUM	72	72	41	72	60	110
PHENOLIC RESIN	20 (+1.25%)	20 (+4.25%)	1.5 (+5.2%)	5 (+3.2%)	4.5 (+5.0%)	24 (+2.7%)
ACETONE, C.C.	85	85	60	85	60	150
POWDER FINAL CHEMISTRY EXCLUSIVE OF BINDER & MIXING RES						
CALCULATED % Ni =	82.44	84.80	74.25	80.25	62.6	85.53
Al =	15.20	15.20	18.50	15.20	20.8	12.0
Si =	1.60			2.70		1.67
B =	0.76		7.25	1.85	16.6	0.80
O_2 =						
SIEVE ANALYSIS - %						
+80 MESH =	0.98	0.98	1.17			
100 =	17.30	22.80	12.60			
140 =	31.00	41.60	28.20			
200 =	29.36	18.20	31.20			
250 =	16.00	9.80	12.40			
325 =	5.36	6.62	4.33			
PAN =	0	0	0			
TUTING BEND TEST	O.K.	0.14	O.K.	PEELED	PEELED	O.K.

50100

NOTE: Sample #6 was ball milled 1½ prior to agglomeration.

E16-1

DEFENDANT'S EXHIBIT V

4. The nickel oxide/aluminum powder from you.

5. Discrete nickel powder - aluminum powder mixed according to what's his name's suggestion.

6. The very recently received version of nickel aluminide from Yuraske.

The intent, of course, is to get an outside opinion of these materials wherein it is deposited either with Metco equipment or the Model U prototype (which supposedly can handle this type of powder).

I would recommend that all tests be conducted on grit blasted surfaces with the request that each powder be rated relative to the standard Metco nickel aluminide.

JPB/ms
Att.

160-6
20 Cec 150
110
24 (+ 2.7%)
150
85.53
12.0
1.67
0.80
O.K.
DEFENDANT'S EXHIBIT V
E16-1

E 18

J. Quaas 4-10-70

G. Yurasko

Nickel-Aluminide, Samples 160-1 through 160-6

Compositions and procedure used in preparation of subject samples follows:

PROCEDURE

General procedure was to pre-mix the -170+325 mesh nickel base component with the -40 aluminum for ten minutes in a small tumbler which we constructed for these preliminary tests. To this was added the Durite phenolic resin binder to form a slurry. The entire mass was then tumbled for one hour, after which all the acetone was evaporated leaving agglomerates 1/4" by down. Agglomerates were crushed to -80+250 mesh in a mortar, dried for one hour at 325°F to set the resin, and finally rescreened -80+250 mesh prior to spray testing.

I might point out that the procedure used in these tests will not be the one used when materials on order are received. Particle size of the aluminum used in these tests was not fine enough to form a true layer or film on the nickel base material; therefore, the agglomeration technique was used.

COMPOSITIONS

See attached data sheet and Quality Control test report.

GY:ld
Att.

Def. Exh. 59 WM
10/4/73 WD

50093

DEFENDANT'S EXHIBIT Z

E 19

(ii)

RESEARCH REPORT

CODE NO: Exothermic Powders - Spram Tests

DATE: 4/15/70

TEST REQUESTED BY: Mr. Broderick

TESTED BY: J. Martens

MATERIAL FROM:

QUANTITY SUBMITTED:

SIZE	CORE	COATING
ELECTRODE:		
ROD:		
FLUX:		
OTHER:		

COMPARED TO:

TEST RESULTS:

R&D Samples:

69A-1) from Quaas
69A-2)

rejected - peel off -

Ni-Al samples from Dept. 160:

160-1)from
160-2)Yurasko
160-3)
160-6)

ran OK
pending metallography

Cerac Exotherm Powder:

-150+200 sieve shows favorable performance through Spram torch
Metco 404 - comparator used

Powders available in Spray Lab.

JM/ms

COMMENTS:

50192

DEFENDANT'S EXHIBIT AA

E 20

O. Knotek

Mr. G.H. Kapralos

Mr. A.G. Gigon

Mr. F.W. Glaser
Mr. J.F. Quaas

20th of May, 1970 /awr

application for nickel aluminide and chromium-carbide - your letter to Mr. Gigon of 1st May.

The jet engine repair is done in different shops in Europe. Since this job is connected to the safety instructions, we need the enlisting of our powders in the specifications of the jet engine producers, i.e. Pratt & Whitney or General Electric. Up to now our products have not been listed in their specifications and we have therefore asked for several times to act in this matter as quickly as possible.

There are just a few cases for which such specifications are not needed any more.

Best regards,

Prof. Dr. O. Knotek

Def. Exh. 47 W.
9/11/73

DEFENDANT'S EXHIBIT AC

50556

E 21 (10)

Nickel-Aluminide
160-16A - 160-21
Yurasko/
Constantina

6/3/70

R. Carroll

7 samples

Parameters:

These parameters were used for all powders in this series of tests:

A standard Spram torch was used.
All test plates were cleaned with acetone and roughed up with coarse grade emery.
Bond test plates are 3" x 6" x 1/16".
Overcoat test plates are 2" x 6" x 1/4".
Preheat was approx. 200-300°F.
Spray distance - 8"-9".
Coating thickness - .006-.008".
Bend test consists of a 180° bend.
Overcoat test consists of overcoating the nickel-aluminide coating with .070" of 13496 powder.
This test was stopped when the coating started to lift off the plate.

N-A 160-16A:

Fuming is medium.
Glaring is bright.
No bounceback noted.
As-sprayed condition is fairly smooth and dark gray in color.
A light fuming residue is noted.
XXXXXXXXX Bend test reveals no coating liftoff.
The coating started lifting at approx. .065".

50168

DX
AM-1

N-A 160-17B:

Fuming is medium.
Glaring is bright.
No bounceback noted.
As-sprayed condition is as smooth as 16A sample.
but lighter gray in color.
A very light fuming residue is observed.
Bend test reveals light coating peel off at edges of
bend only.
The coating lifted off at approx. .063".

N-A 160-17C:

Fuming is heavy.
Glaring is very bright.
No bounceback is noted.
As-sprayed condition is rougher than 16A and 17C and
dark gray in color.
A medium amount of fuming residue is observed.
Bend test reveals no coating liftoff.
No liftoff at .070" coating.

N-A 160-18:

Fuming is heavy but less than 17C and 19.
Glaring is very bright.
No bounceback noted.
As-sprayed condition is rough anddark gray in color.
A light fuming residue is evident.
Bend test shows no coating liftoff.
Liftoff of coating occurred at apprx. .070".

N-A 169-19:

Fuming is very heavy.
Glaring is very bright.
No bounceback noted.
As-sprayed condition is fairly smooth
and gray in color.
A heavy amount of fuming residue is noted.
Bend test reveals no coating peel off.
No liftoff at .070" coating.

N-A 160-20:

Fuming is light to medium.
Glaring is bright.
No bounceback noted.
As-sprayed condition is rough and gray in color.
A light to medium amount of fuming residue is noted.
Bend test reveals no coatingpeel off.
Coating lifted off at apprx. .065".

N-A 170-21:

Fuming is very heavy.
Glaring is very bright.
No bounceback noted.
As-sprayed condition is rough and gray in color.
A heavy fuming residue is noted.
Bend test shows no coating peel off.
No coating liftoff at .070".

RC/ms

Deft's Ex 25 FOR ID MC 9/7/73

E 24

Exothermic Powders 6/12/70

Mr. Broderick R. Carroll

A blend of 404 nickel-aluminide with a tungsten carbide/ matrix similar to Metco and one with Eutectic standard powders was made. The constituents and their percentages are as follows:

Metco Blend (XP-1139)	Eutectic Blend
50% - 1279B	50% 1279B
35% - 15E	35% 13496
15% - 404	15% Ni-Al #14 -100+325 mesh

Both powders were sprayed through a Metco 5P gun using the followingparameters:

P7B nozzle
#12 meter valve
#17 flow control valve setting
Flow meter readings: Oxy 32 Acet 32
Spray distance 7-10"
In both cases, the powder was applied to grit blasted and emery cleaned plates.
Fuming is heavy.

50147

DX
AP

Glaring is heavy.
No bounceback noted.
As-sprayed condition compares to standard.
Similar heavy fuming residue noted on plates.
The coatings were examined under a microscope and are similar in respect to roughness and carbide content.
Both powders are also self-bonding to mild steel plates.

The nozzle was changed to P7-G and the meter valve to #11 with no better results.

RC/ms

E 26

DX 3

EUTECTIC CORPORATION

40-40 172nd STREET · FLUSHING, NEW YORK 11358 · 212 359-4000

NAPPALOS
PRESIDENT

AI

July 10, 1970

Mr. Vernon Cook-President
Metallizing Co. of America
3520 W. Carroll Avenue
Chicago, Illinois 60625

Dear Vern:

To confirm our telephone conversation, I am pleased to advise that we can offer to you our BN9048 product which is equivalent in every respect to the Metco 450 product.

BN9048 has a nominal composition of 4.5% aluminum, nickel balance. The normal particle size range of the product is -170 +325 mesh but can be provided in any particle size range you may specify. The typical bond strength of BN9048 is in excess of 3100 psi and coatings of this product can be machined with carbide tools.

We shall be pleased to supply this product to you under our standard patent infringement indemnity conditions. In the event anyone alleges, or files a patent infringement suit on the basis that our BN9048 product infringes any United States Patent, we shall defend such suit and shall save your company harmless from liability. You are required to notify us promptly in the event any patent infringement situation arises and of course we would expect your cooperation in providing to us the pertinent information we would require in any such matter.

For your information, we have sold this product to a number of customers, including several hundred pounds on bid to a U.S. Navy Air Station. The Navy order was slated to go to the competitor, but our bid was slightly lower. To date the competitor's only reaction has been an attempt to work out with the technical people at the Naval Station, a modified specification.

DX
AU

50002

JUL 13 19

E 27

Mr. Vernon Cook

July 10, 1970

Our prices to you for the BN9048 product shall be as follows:

100 to 300 lbs.	$7.45 per pound
301 to 1,000 lbs.	$7.05 per pound

If I can supply any additional information, please do not hesitate to contact me. Please forward any purchase orders to my attention. Purchase orders should be addressed to our subsidiary company for special accounts which is

New Metals Corp.
171-20 Station Road
Flushing, New York 11358

With kindest regards, I am

Very truly yours,

Harry Kaprilos

HK:hpc

E 28

c.c. J. Dennis

10(c)

ROUND TRIP LETTER

TO J. Fennick

DATE 12/5/44 SUBJECT No-111 19303 - Lot #6 115#

We have received fee clearance from previously reported (Low-11) Lot #6.

Would you please have D.E. run one rounded watch in order to maintain effect, if D.E. is "OK" we should then proceed with hand fitting per Tanzmans recommendations.

This particular shield also be tested using spring pin.

SIGNED J. Fennick DEPT.

DATE SIGNED

DX
BN

50194

Def. Exh. 110 M
11/15/51 DB

E 29

91

Dr. Rene D. Wasserman

G. H. Kapralos

EXOTEC

9/3/73

F. W. Glaser
J. P. Quass
T. P. Bronco
A. C. Gigon
F. Brandenberg
J. Cnders
J. Broderick

This memorandum is in response to your request for additional background information and applications relative to EXOTEC.

Prior to the advent of exothermic bonding materials, molybdenum wire, sprayed via wire guns, was the only material that could be utilized as a base bond undercoat for subsequently metallized surfaces. A base bond undercoat is a substrate layer of material that is applied directly to the base metal. The final overlay alloy is sprayed thereafter directly over the base bond. The use of a base bond undercoat came into being as a preparatory coating in metallizing applications because the base bond was found to provide a stronger bond to the base metal with greater integrity for metallized coatings than that obtained when spraying the overlay alloy directly to the base metal. Also the use of a spray bond undercoat provides better bonding while eliminating the need of elaborate surface preparation such as sandblasting.

Molybdenum, when used as a bonding undercoat, requires a high degree of proficiency on the part of the workman. Tip to work piece distance is critical, and gas flows are also extremely critical. Moly wire depends greatly upon pure art in application rather than science. These factors, of course, make it extremely vulnerable to failure. Moly wire also cannot be used on hardened metal surfaces.

Our optimism over the market potential of EXOTEC is that EXOTEC has none of the disadvantages associated with molybdenum and, in addition, provides many distinct advantages. EXOTEC has much greater bond strength than moly and can be applied with ease. EXOTEC has the ability to withstand temperatures up to 1500°F which is highly desirable. As an example, oxidation resistant coatings can be used on top of EXOTEC.

EXOTEC, in all cases, improves the bond strength to the base metal of subsequent spray build-up coatings (also known as metallized coatings). It provides more latitude in application where preparation or size presents a problem. Regardless of the preparation method used on the base metal prior to spraying, it increases the integrity factor. It is possible to apply EXOTEC to a surface which has been merely ground or cleaned with abrasive papers.

DX
BS

Def. Edu. 50 yd

9/11/73

50302

September 3, 1970

Dr. Rene D. Wasserman

In order to illustrate this, we have seen that it was possible to reclaim an automotive engine block head surface by first grinding, spraying EXOTEC and then building up with SPRAM alloy 14493. This build-up coating was then finish ground in a standard engine block grinder. At the time of this demonstration, repairs were also made on this engine block in the main bearing saddles. We feel that the Automotive Industry is an important area for sales development. As a result of our sales research in the use of EXOTEC in the repair of engines, Mr. Doody has set up a demonstration and research project for applications to army vehicle engine reclamation. During this project we will investigate the integrity of EXOTEC bonded coatings for crank shaft journals.

We have a great deal of interest from paper companies who have massive rolls. These rolls cannot be overlayed with other welding processes. We have successfully spray coated these rolls on several occasions. Early reports indicate that we may also have a wide area of application in the Wire Drawing Industry on blocks and capstons. We are awaiting service performance on these tests. Colorado Fuel & Iron Corporation is awaiting our quotation for 25 lbs. of EXOTEC as an initial order for wire drawing block reclamation. There are many more application areas to be developed.

We are carefully accumulating and evaluating these success stories so that they can be utilized to promote EXOTEC and the SPRAM Process. This information will also be utilized through our internal literature so that all of the Field Force will be aware of these successes and in turn, develop them in their own area of endeavor. A case history summary of the good applications will be forwarded shortly to Europe and International areas.

Because of a shortage of pure nickel powder we had thus far released EXOTEC to only 14 Industrial Powder Division Specialists. We have now received ample raw material and we are planning a broader release.

The Specialists that have had EXOTEC report that EXOTEC provides to the customer, a more versatile tool. In many instances, it is reported that the sale of a SPRAM Gun was made because the customer could use this tool for both metallized type coatings as well as fused coatings. We all know that a demonstration which has impact on the customer is extremely important. EXOTEC gives us this remarkably demonstrative impact. The salesmen who have demonstrated EXOTEC relate that customer response is "fantastic, amazing", and they also relate that it draws crowds as the demonstration is progressing. Several of the salesmen relate that it is easy to sell the SPRAM Gun when you have EXOTEC.

50303

September 3, 1970

Dr. Rene D. Wasserman

I personally feel that the exothermic type materials could be the cornerstone of a very important sales volume. As you can appreciate, this product will certainly illustrate to the marketplace, that we are indeed, an innovative company who can develop new application ideas of value to the customer.

The Industrial Powder Division Specialists who have worked with the Field Force, have been helpful in accumulating classic product business where the SPRAM unit is demonstrated and sold. We feel that this is due to the impressive demonstration and the prestige gained with SPRAM powders. We have several reports from the Industrial Powder Division where sales have been recaptured and also where these experienced welding sales people have assisted the Eutectic Field Force in increasing sales of classic products. SPRAM has made possible entry into plants which were formerly inaccessible. In fact, several Eutalloy Torches have been sold as a result of having introduced SPRAM to these customers. SPRAM also is a true GUIDED COURSE Process. I am told, that where reluctance has been shown by a customer for a GUIDED COURSE, SPRAM has been the entre weapon and allows demonstration of classic products.

There are a number of interesting EXOTEC products to be released shortly, including an aluminum bronze, EXOTEC-carbide blends and EXOTEC-carbide self-fluxing alloy blends.

Advance information on EXOTEC and samples have been, and are being, forwarded to Europe, Canada, Mexico, Japan and Australia. A formal Europe and International Division release (with applications and all pertinent data) is being finalized and will be released shortly.

If you require additional information, please advise.

GHK.ks

50304

DX 32 E 32

F. Wishnie
J. F. Broderick
METCO 405

10/14/70

J.F. Quaas
G.H. Kapralos
D.P. Tanzman

Separately, we have ordered Metco 405, 1/8". In your stock, you should have 1/8" pure molybdenum wire as supplied by Mogul.

1. Establish operating parameters for the Mogul moly wire in the Mogul Wire Gun.

2. Explore operating parameters for depositing Metco 405 in the Mogul wire gun.

We will shortly receive developmental Blitz type Exothermic tubular wire from Baltimore and the above is required for comparison purposes.

JTB/ms

BU

50582

DX
BU

E 33 91

INTER-OFFICE CORRESPONDENCE

TO: J. F. Quaas DATE: Nov. 10, 1970

FROM: J. W. Reuter

SUBJECT: PRATT & WHITNEY

CC: H. Kapralos
J. R. Onders
D. Tanzman
A. Mallin
M. Turk

Some time back we discussed manufacturing 100 pounds of powder to meet Pratt & Whitney specification, which we would give them at no charge for their testing.

If we will certify that our EXOTEC powder meets the attached specification, they will go ahead and evaluate. Without certification it might take six months to a year to get their approval.

Please advise.

J. W. Reuter

JWR/ed
Attach.

It's great to be with EUTECTIC TWO WELDING COURSES A DAY

Def. Eth. 5.1 ud -
9/11/73

50297

DX
BW

E 34

11/11/70

Mr. J. W. Reuter
J. F. Quinn
Pratt & Whitney

Messrs:
H. Kapnalos
J. Childers
D. Tenzman
A. Hallin
M. Turk
M. Doody

I make reference to your letter dated November 10th.

Mr. Tenzman has been instructed to provide 100 lbs. of material which will meet the P&W spec and to which we will certify.

JFQ:ml

Def. Sch. 65
10/4/73

50573

DX
Bz

E34-1

Internal Correspondence
Flushing

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Continuous Electrodes • Powdered Alloys • Chemical Aids and Fluxes

Date January 26, 1972

To Mr. J. E. Quaas

From Mr. M. Patel

Copies Mr. J. Broderick

Subject

EXOTEC 29904 BOND STRENGTH

The bond strength of standard Exotec 29904 has been measured compared with Metco 450. The bond strength of both powders was evaluated on the RoToTec Torch and the N Gun. The results are as follows:

1. Exotec 29904 (Lot 385)

   With RoToTec : 3020 psi (Avg. of 3)
   With N Gun : 2650 psi (Avg. of 3)

2. Metco 450 (Lot 6424)

   With RoToTec : 2340 psi (Avg. of 3)
   With N Gun : 2260 psi (Avg. of 3)

The bond strength of Exotec 29904 using RoToTec Torch is approximately 15% higher. Incidently, the addition of 2% yellow color in one Exotec powder will add even much higher bond strength than competitive powder.

If you need any further information, please advise.

MP:hpc

DX
CQ

50587

E34-2

nternal Correspondence
Flushing

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and Repair Welding Techniques®
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Continuous Electrodes • Powdered Alloys • Chemical Aids and Fluxes

Date April 20, 1972
To Mr. M. Patel
From Mr. B. Brachfeld
Copies Mr. J. F. Quaas

Subject
RESULTS OF X-RAY DIFFRACTION STUDY OF Ni-Al POWDER SPRAYED INTO AIR - EUTECTIC 29904 & METCO 450

A previous X-ray diffraction study of Ni-Al powder sprayed on test slugs found no Ni-Al compound to be present. In this study, instead of being sprayed onto test slugs, the powder was sprayed into the air and collected in a bucket. In this way the powder would be cooled down to room temperature at a slower rate than previously, which might enhance the formation of a Ni-Al compound.

X-ray diffraction analyses of Eutectic 29904 and Metco 450 powders, prepared in the above manner, revealed the presence of Ni, Al and their respective oxides. Once again, no Ni-Al compound could be found.

BB:hpc

DX
CR

5C441

ABSTRACT OF THE INVENTION

This invention encompasses the structuring of a multicomponent particle which, upon being subjected to a heat zone, such as the flame area of an oxy-acetelene torch, will self-react to promulgate an exothermic reaction resulting in the generation of a sufficiently large amount of heat to super-heat the particle and permit such superheated particle, upon being propelled to a surface, to adhere to such surface. This multicomponent particle is provided with a catalystic element to react with other elements in the particle system to create a surprisingly superintensified but momentary high heat energy output reaction to create a superior, widespread and stronger bond between the propelled particle and the base surface.

The art of flame spraying involves the feeding of alloy powders or alloy wires into a heating zone such as the flame of an oxy-acetelene torch, whereby the powders or wires are heat softened. The heat softened alloys are then propelled from the heat zone into a surface to be coated. It is known in prior art practices that in flame spray applications, to assure a mechanically sound bond between the base surface and the sprayed material, the base surface must be sand or grit blasted. Sand or grit blasting as an operation represents many undesirable defects including the existence of many work pieces that can not be sand blasted because the process will introduce scaling or permanent deformation in the work piece.

DX
CS

As the art of flame spraying progressed, a number of so called self-bonding systems were introduced. These self-bonding systems consisted of two metals which when subjected to heat inter-reacted to generate an exothermic reaction which sufficiently superheated the material being sprayed, to permit, upon contact with the base surface, a microweld bond between the sprayed material particles and the base surface. This process provides a sufficiently good mechanical bond to eliminate the necessity for grit or sand blasting the base surface. It is, however, well known in the art that the momentary exothermic reaction heat generated by these self-bonding systems is not sufficient nor lasting to permit all of the sprayed particles to microweld upon the base surface. Indeed, it is generally accepted in the art that in the highest performing prior art self-bonding systems, at best, not more than about fifty percent of the sprayed particles became microwelded to the base surface. Further, due to the minimal exothermic reaction heat energy dissipated by the prior art self-bonding systems, the proper application of the prior art self-bonding systems is extremely skilled and fixed condition sensitive. It is well known in the flame spray art that a variance in the optimum operating conditions or a slight operator error will result in an insufficient amount of self-bonding system particles becoming microwelded to the base surface. This will result in the mechanical separation of the coating from the base surface when a work piece thus prepared is placed in service.

It is the general object of the present invention to avoid and overcome the prior art practices by providing a self-bonding system that will generate a significantly greater amount of momentary exothermic reactive heat output.

Another object of the present invention is to provide a self-bonding system in both powder and continuous wire forms, which, upon spraying to a base surface, will provide a substantially stronger bond to the base surface.

Yet another object of the present invention is to provide a self-bonding system that will be easy to use.

In view of the inherent limitations of the prior art self-bonding systems, an extensive research program was conducted in the effort to discover an improved self-bonding system. After considerable effort, it was discovered that an unexpectedly high and long lasting exothermic heat output was generated by the addition of certain catalystic compounds which were found to have the ability to cause the prior art self-bonding compounds to react at an unexpectedly higher energy output level. These catalystic compounds such as chromate bearing compounds, peroxides, chlorate bearing compounds, nitrates and bichromates such as, for example, $PbCrO_4$, $ZnCrO_4$, $SrCrO_4$, K_2CrO_4, etc. Na_2O_2, BaO_2, $NaClO_3$, $Ba(ClO_3)_2$, $Sr(ClO_3)_2$, $NaNO_3$, and $K_2Cr_2O_7$, cause the prior art inter-metallic self-bonding compound systems to generate superintensified heat at much higher levels than previously known. This superintensified heat provides to these particles a far superior ability and probability for binding to a sprayed surface.

Ag Ce	Al Te	B Y	Ca Tl	Ga Pr	Li Zn	Pb Pu
Ag Cu	Al Ti	B Zr	Cd Li	Ga Sb	Mg Ag	Pb Se
Ag Ze	Al U	Ba Bi	Cd Na	Ga Te	Mg Ni	Pb Tl
Al As	Al V	Ba Pb	Ce In	Ga U	Mg Pt	Pd U
Al Au	Al W	Ba Sb	Ce Mg	Ge Mg	Mg Sb	Pr Sn
Al B	Al Zr	Be Co	Ce Pb	Ge Nb	Mg Sn	Pr Tl
Al Ba	As Cd	Be Cr	Ce Si	Ge Zr	Mg Te	Sb Zr
Al Ca	As Ga	Be Ni	Ce Sn	In Te	Mg Zn	Se Sn
Al Ce	As In	Be Np	Ce Zn	In Ru	Mn As	Se Th
Al Co	As Mg	Be Pu	Co Si	K Sb	Mo Be	Se Tl
Al Cr	As Zn	Be U	Co Tl	K Se	Mo Si	Si Ta
Al La	Au Mg	Be Zr	Cr Si	K Sn	Na Pb	Si Ti
Al Li	Au Pr	Bi Ca	Cr Ti	K Tl	Na Sb	Si Th
Al Mo	Au Zr	Bi Ce	Cr Zr	La Pb	Na Se	Si U
Al Nb	B Ca	Bi K	Cu Au	La Sb	Na Sn	Si V
Al Ni	B Cr	Bi Li	Cu Fe	La Sn	Na Te	Si W
Al Pd	B Hf	Bi Mg	Cu Mn	La Tl	Na Tl	Si Zr
Al Pr	B Nb	Bi Na	Cu Ni	La Zn	Nb Be	Sn Te
Al Pt	B Ta	Bi Se	Cu Pr	Li In	Nb Si	Sn U
Al Sb	B Th	Bi Te	Cu Pt	Li Pb	Ni Si	Sn Zr
Al Se	B Ti	Bi Th	Cu Te	Li Sb	Ni Te	Ta Be
Al Si	B V	Ca Pb	Cu Zr	Li Sn	Ni Th	Te Zn
Al Ta	B [illegible]	[illegible]	[illegible]	[illegible]	Pb Pr	Ti Zr

Zr Fe Zr Ni Zr Pb Zr Sb Zr Sn Zr W Zr Zn

As an example, the addition of 0.7% to 6% by weight of a catalyst such as $PbCrO_4$, $ZnCrO_4$, $NaClO_3$, etc. to any one of the self-bonding systems produces, upon the application of heat the herein described surprisingly superintensified heat reaction. It was further discovered that particles having a prior art self-bonding system combined with the catalyst, when flame sprayed upon a surface, will result in a far greater number of particles becoming microwelded to the surfac as compared to the number of microwelded particles of the same self-bonding system without the catalyst.

Among the numerous experiments conducted, a prior art self-bonding system was prepared by agglomerating 5% by weight fine aluminum powder with coarse size nickel powder by the employment of any of the agglomerating methods well known in the prior art (hereinafter referred to as System A). The agglomerant was reduced to powder form of a mesh size finer than fifty mesh and sprayed with a flame spray gun to a clean but unblasted steel plate to form a coating. The coating was then peeled off to reveal many nickel particles microwelded to the steel plate.

A second agglomerant batch was prepared with 4% by weight of the herein described various catalyst materials such as $ZnCrO_4$ and 5% by weight fine aluminum combined with the coarse nickel powder (hereinafter referred to as System B). This system also reduced in powder form was flame sprayed through a flame spray gun to a steel plate. The gun was the identical gun used in the above described test. The steel plate was similarly an exact duplicate in

substance, preparation and alloy form to the plate used in the above described test. When each coating was removed it could be easily observed that each System B caused a far greater number of nickel particles to be welded to the steel plate.

Further testing revealed that coatings of various Systems B, when flame sprayed non-blasted steel plates, shafts, and other surfaces, required a significantly higher lift force to peel off than coatings of System A flame sprayed through the same gun on identical base surfaces.

It is obvious, therefore, that the catalyst interreacts with a self-bonding system to provide a superintensified but momentary heat reaction of a significantly higher magnitude than that which is produced by the self-bonding system without the catalyst. The self-bonding system of this invention, therefore, heated and applied on a surface will provide a widespread and stronger bond between the sprayed material.

Self-bonding system compounds of the present invention can be agglomerated and crushed into powder form or formed, by a number of well known methods such as extrusion, into rod and wire forms.

It will now be understood by those skilled in the art that the objects of this invention have been achieved by the provision of a self-bonding system that will provide upon heat application and spraying to a base surface, greater heat energy output and a widespread and stronger bond between the sprayed material and the base surface.

CLAIMS

We Claim

1. A system comprising:

   a. at least two elements which upon the application of heat will react to generate additional heat; and

   b. a catalyst.

2. The system of Claim 1 wherein said catalyst is taken from the group consisting of chromate bearing compounds, peroxides, chlorate bearing compounds, nitrates and bichromates.

3. The system of Claim 1 in powder form.

4. The system of Claim 1 in rod form.

5. The system of Claim 1 in wire form.

E 42

Internal Correspondence
Flushing

Eutectic + Castolin Institute
for the Advancement of Maintenance
and Repair Welding Techniques®
PERMANENT TECHNICAL ASSISTANCE

Fusive Processes • Wearfacing Alloys • EutecRod Alloys • EutecTrode Alloys
Continuous Electrodes • Powdered Alloys • Chemical Aids and Fluxes

Date June 15, 1972
To J. F. Quaan
From J. P. Broderick
Copies

Subject
Dave McDonald - California

For your information, Gene Counts, the Regional Manager in Oakland, hired a young man by the name of Dave McDonald (IBM#9711) on May 1, 1972 who worked several years for United Aircraft as a powder spray technician.

I had several occasions to talk to McDonald who seems to know what he is doing. One of the statements he made was the fact that United is buying large quantities of Metco 450 for building up turbine shrouds. This is the application wherein the turbine wheel actually wears into the nickel-aluminide coating seating itself. Previously, a special honeycomb metal was used that was quite expensive.

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Internal Correspondence
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Eutectic + Castolin Institute

for the Advancement of Maintenance
and Repair Welding Techniques®

PERMANENT TECHNICAL ASSISTANCE

Exclusive Processes • Wearfacing Alloys • EutecRod® Alloys • EutecTrode® Alloys
Continuous Electrodes • Powdered Alloys • Chemical Aids and Fluxes

Date June 19, 1972

To Mr. J. F. Quass

From Mr. M. Patel

Copies

Subject
XUPER BOND PWA SPEC 1337
Re: Your Memo of June 14, 197

In response to your memo of June 14th, 1972, reg :ding Xuper Bond meeting PWA 1337 specification, it is correct that the new product does not meet exact 133? specification.

The 1337 specification allows 2.5% maximum impurities as volatile phenolic binder. Exotec 29904 has approximately 1.5% resin as impurities. In addition to resin contents, if we use 1% lead chromate as catalyst it can bring Xuper Bond into PWA 1337 specification. Presently, I am using 2% lead chromate which gives 25% more bond strength. It will give 10-15% more bond strength if we use 1% lead chromate.

M.P.

MP:hpc

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Internal Correspondence
Flushing

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PERMANENT TECHNICAL ASSISTANCE

Exclusive Processes • Wearfacing Alloys • EutecRod® Alloys • EutecTrode® Alloys
Continuous Electrodes • Powdered Alloys • Chemical Aids and Fluxes

Date October 24th, 1972
To Mr. J.F. Quaas
From M. Patel
Copies

Subject
New Powders -
XuperBond, 19112 and 19222
Mr. Steine's Report

The report on "New RoToTec Powders - 19112, XuperBond and 19222" by Mr. Steine is very interesting. The metallographic pictures of XuperBond, 19112 and 19222 are excellent and reveal the true nature of the sprayed coatings.

Xuperbond Powder

XuperBond powder is an exothermic powder which has a better bond strength than Exotec 29904 powder. The powder has a 2.5 - 3% higher catalytic additive which reacts during spraying and intensifies the heat output per composite particle. This intensified heat output plus exothermic reaction superheats particles and creates more microwelded particles and more oxides than Exotec 29904.

The report indicates lower deposition efficiency and lower flow rate for Exotec 29904 and XuperBond powders. The deposition efficiency is measured on a grit blasted 6" x 12" x 1/16" thick 1020 steel plate. Usually, Exotec 29904 and XuperBond spray at the rate of 5-6 lbs/hr. and have a high deposition efficiency up to 90%. The reported low spray rate could be attributed to moisture in the valve or dirt in the RoToTec torch. If the torch is properly cleaned and deposition efficiency is measured according to the prescribed method, it should show a higher spray rate and high yield.

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Internal Correspondence
Flushing

Date October 24th. 1972

To

From

Copies

Subject

New Powders

Eutectic + Castolin Institute
for the Advancement of Maintenance
and Repair Welding Techniques
PERMANENT TECHNICAL ASSISTANCE

Exclusive Processes • Wearfacing Alloys • EutecRod Alloys • EutecTrode Alloys
Continuous Electrodes • Powdered Alloys • Chemical Aids and Fluxes

19112 Powder

The metallographic picture in Mr. Steine's report is an excellent presentation of the sprayed coating. The picture shows WC particles, oxides, and few porosities.

The powder is formulated to use when heavy build-up and high wear resistance are required. The wear resistance measured in Flushing is measured using coarse sand as an abrasive. All hard sprayed coatings do not have high resistance against sand blasts. It has been our experience, that usually soft coatings have good resistance against high velocity sand blasts.

The report shows again, a low spray rate and low deposition efficiency which is probably due to a faulty valve and the moisturous condition of the spray torch.

19222 Powder

The Mr. Steine report shows an excellent presentation of 19222 sprayed coating. The coating has very few porosities, oxides and good mechanical bonding.

The report indicates the 19222 powder having a low spray rate and very poor flow rate. This may be, as previously mentioned, attributed to a moisturous condition and faulty torch valve. Our experience shows 85% min. deposition efficiency at 4.8 lbs/hr.

MP:cb

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Eutectic-Castolin Institute
FOR THE ADVANCEMENT OF MAINTENANCE AND REPAIR WELDING TECHNIQUES

EXECUTIVE OFFICES

October 26, 1972

SOME STRAIGHT TALK ABOUT XUPERBOND...

Fact: XUPERBOND IS SUPERIOR TO ANY BONDING POWDER PRESENTLY AVAILABLE ON THE MARKET TODAY... INCLUDING EXOTEC 299041

Fact: XuperBond has been specially formulated to provide an oxidant for total reaction purposes. Not only does the oxidant accelerate the self-reaction characteristics of the powder in the flame, but it produces optimum bond strength to the parent material.

Fact: Field trips have indicated to me that greater attention should be focused on proper tip-to-work distance parameters when using XuperBond in order to take advantage of its inherent, excellent characteristics. At all times, no matter what size of shaft, the tip-to-work distance should be maintained at 8" to 6". It is within these parameters that highest bond strength levels are obtained.

Fact: If the spray distance is below 6", for example 5", the bond strength will be lowered approximately 20%. If the spray distance is in excess of 8", the bond strength is affected only slightly but the deposition efficiency declines. Proper preparation plus avoidance of overheating the parent material results in complete reliability of the Roto'Tec Process and its consumables.

(cont'd)

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If you have, or you do, experience any difficulties with XuperBond, I suggest you and your customers check the following key procedural steps that must be rigidly enforced in order that 100% results be enjoyed. In sequence they are:

DJ

1 - Cleanliness. No grease, moisture or contamination on the surface to be sprayed.

2 - Proper threading of the undercut, with a 90° type tool.

3 - Proper minimum and maximum application temperatures:

Minimum preheat - 200°F.
Maximum spray heat - 500°F.

4 - Proper tip-to-work distance: 8" to 6" with the longer distance favored.

5 - Proper finishing of the applied coating using a carbide-tipped tool bit for all machinable coatings.

Remember! The most important, single factor to concentrate on when spraying XuperBond is to favor the 8" spray distance. The 8" spray distance will compensate for any tendency to drift in with the RotoTec Torch.

XUPERBOND IS EXACTLY WHAT WE SAY: the BEST BOND COAT POWDER AVAILABLE. Take advantage of its excellent properties by following the 8" to 6" spray parameters and the necessary procedural steps outlined previously.

Sincerely,

Joseph F. Quaas
Senior Vice President

vf

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E42-6

November 3, 1972

Dr. C. Vuillaumier

J. F. Quaas

New Powders -
XuperBond, 19112, 19222

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I make reference to your letter dated August 30th and to Mr. Staine's report of the same date.

The samples of the three powders previously evaluated by Mr. Staine represented original formulations prepared on our laboratory MSA equipment.

These three powders have now been produced, time and again, on a plant basis, and I have requested Mr. Broderick to forward to your attention samples of the XuperBond, 19112 and 19222 materials for re-evaluation purposes. These three samples are representative of those materials which we are now selling.

I attach a copy of our Mr. Patel's comments as reflected in his letter dated October 24th and which covers the 19112 and 19222 products.

In the case of the XuperBond powder, it is similar to the ExoTec material except that its formulation contains a low percentage of an | additive which reacts during spraying and intensifies the heat input in each powder particle during the interim that particle is in the flame. In effect the powder particle is superheated to some extent and therefore creates more micro-welded particles and, to some extent, additional | when compared with the prior ExoTec product.

Mr. Patel also reports to me that Mr. Staine's report dated August 30th indicates a lower deposition efficiency and a lower flow rate for ExoTec and the XuperBond original sample, when compared with the results as we know them in Flushing. We measure the deposition efficiency on a grit-blasted 6" x 12" x 1/16" thick 1020 steel plate. Normally, both the ExoTec and the XuperBond powders spray at a rate of 5 to 6 lbs. per hour with a deposition efficiency of 20%. Mr. Patel is of

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the opinion that perhaps moisture in the valve or foreign material in the RotoTec Torch may be the cause for the values reported by Mr. Steine.--

Our experience, also, in the field since the release of the new XuperBond product has indicated that an 8" spray distance (tip to work distance) will provide optimum bond strength levels. Our field people have been instructed to always employ an 8" to 6" tip to work distance with the new XuperBond material. We have paraphrased our instructions this way in order to convey to them that the 8" distance is the more favorable.

JFQ:ml

Metco 54 Aluminum Powder --200+325 mesh - 2-1/2 lbs. - 6/18/64 (DR)

Metco 12C - Fed. Mog. - 864LC --150 +325 mesh -1sample Q-928 -11/10/64

Metco 15E - Fed. Mog. -860 - -150+325 -sample Q-929 11/10/64

Metco 16C Powder - 1-5# Can - 7/21/65

Metco 31C (T/R Mosman) - 1/12/66 - 1 module

Metco 450 Powder - 2# - 6/6/67

Metco 16C Powder - 2 cans - 7/11/67

Metco 34F Powder - 10 lbs. - 9/14/67

Metco 14E powder - 10# - 11/28/67

Nickel-Aluminide powder - 10# - 5/7/68

15E - 10# - 5/16/68

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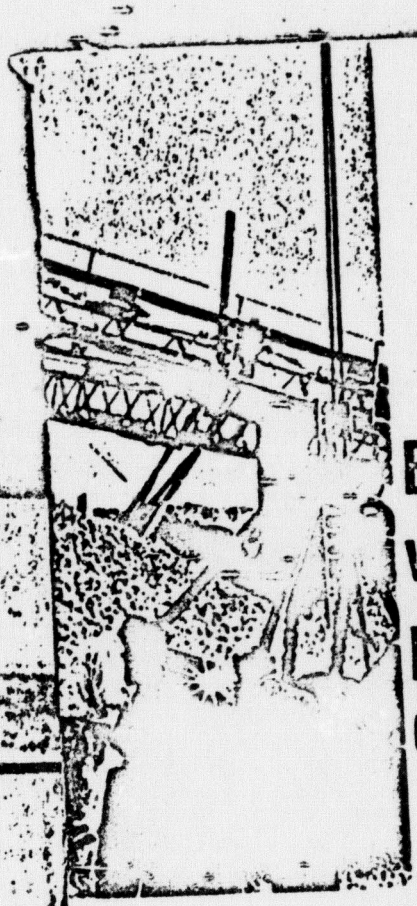

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Eutectic•Castolin welding pocket data book

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EUTECTIC•CASTOLIN INSTITUTE
FOR THE ADVANCEMENT OF MAINTENANCE AND REPAIR WELDING TECHNIQUES
40 40 172nd Street, Flushing, New York 11358
Sponsored by the Eutectic Corporation,
A MEMBER OF THE EUTECTIC CASTOLIN GROUP OF COMPANIES

The RotoTec Process...

A "cold" process overlay system.

RotoTec is a new flame spray process for restoring worn bearing areas on cylindrical parts such as shafts, rolls, journals, axles, etc.

It utilizes oxy-acetylene to melt and project alloy particles onto a worn part as it rotates in a lathe.

Parts to be repaired are first thoroughly degreased. The worn area is undercut and threaded. This preliminary procedure produces an ideal "rough" surface of clean base metal onto which subsequent coatings adhere.

All RotoTec coatings are made up of two "layers" . . . consisting of an initial bond coat layer of EXOTEC 29904 . . . followed by one of the final alloy coatings. (see page 149)

The main advantages of the RotoTec Process are:

1) Workpiece need never be heated to above 500°F. . . . eliminating all dangers of undesirable effects caused by overheating.

2) Repairs are achieved rapidly and simply . . . No special skills or techniques are required. Equipment is simple to understand and master. Buildup of new metal proceeds smoothly from start to finish. Basic lathe skill is all that an operator needs to get reliable, professional results.

3) Coatings produced are extremely reliable and long-lasting. They offer exceptional resistance to metal-to-metal wear. Range of final coatings available include MACHINABLE, NON-MACHINABLE and ALUMINUM BRONZE. RotoTec coatings are completely bonded in the as-sprayed condition . . . requiring no extra "fusion" steps.

RotoTec Alloys . . . F
Metallized Coatings . .
Use With The RotoTec

BOND COAT (Initial layer for

XUPERBOND XuperBond is which develops bond strengths o bonding materials. It is recommen applications such as inside diam quired. XuperBond is particularly recommended spray parameters ar color for easy identification.
FOR USE ON THE FOLLOWING BAS
All except pure copper
DEPOSIT EFFICIENCY 95%
RECOMMENDED COATING THICKN

EXOTEC 29904 is a uniq special formulation produces a l action during deposition. The imp on the prepared substrate (base m Interlocked structure of the solidi face for all subsequent final coats.
FOR USE ON THE FOLLOWING BAS
Ferrous Metals • Cast Iron • Nickel
DEPOSIT EFFICIENCY Over 90%
RECOMMENDED COATING THICKN
FINAL COATS

DIAMAX 19112 is the first fully adapted for wide gap metal s urated dispersion of ultra-bond mi unprecedented degree of abrasion can be ground to a smooth, low-fri "as-sprayed" condition to utilize th

DIAMAX 19112 is specifically desig abrasion is present and where the p the mating surface.
FOR USE ON THE FOLLOWING BASI
Ferrous Metals • Cast Iron • Stainle
DEPOSIT EFFICIENCY Over 90%
MACHINABILITY Finish by grinding.

restoring worn
as shafts, rolls,

t alloy particles

degreased. The
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EXOTEC 29904
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NUM BRONZE.
the as-sprayed
eps.

RotoTec Alloys . . . For 1-Step "Cold" Process Metallized Coatings . . . Designed Exclusively For Use With The RotoTec Gun

BOND COAT (Initial layer for all coatings)

XUPERBOND XuperBond is a premium bonding coat alloy powder which develops bond strengths of up to 50% higher than conventional bonding materials. It is recommended especially on all unusual or "difficult" applications such as inside diameters or where heavier buildups are required. XuperBond is particularly valuable when chances of variation in recommended spray parameters are high. XuperBond has a distinctive green color for easy identification.

FOR USE ON THE FOLLOWING BASE METALS
All except pure copper
DEPOSIT EFFICIENCY 95%
RECOMMENDED COATING THICKNESS Between 0.004" and 0.008"

EXOTEC 29904 is a unique, self-reacting, composite powder. Its special formulation produces a powerful exothermic (heat-releasing) reaction during deposition. The impact of the superheated powder particles on the prepared substrate (base metal) achieves metallurgical-type bonding. Interlocked structure of the solidified particles provides the optimum surface for all subsequent final costs.

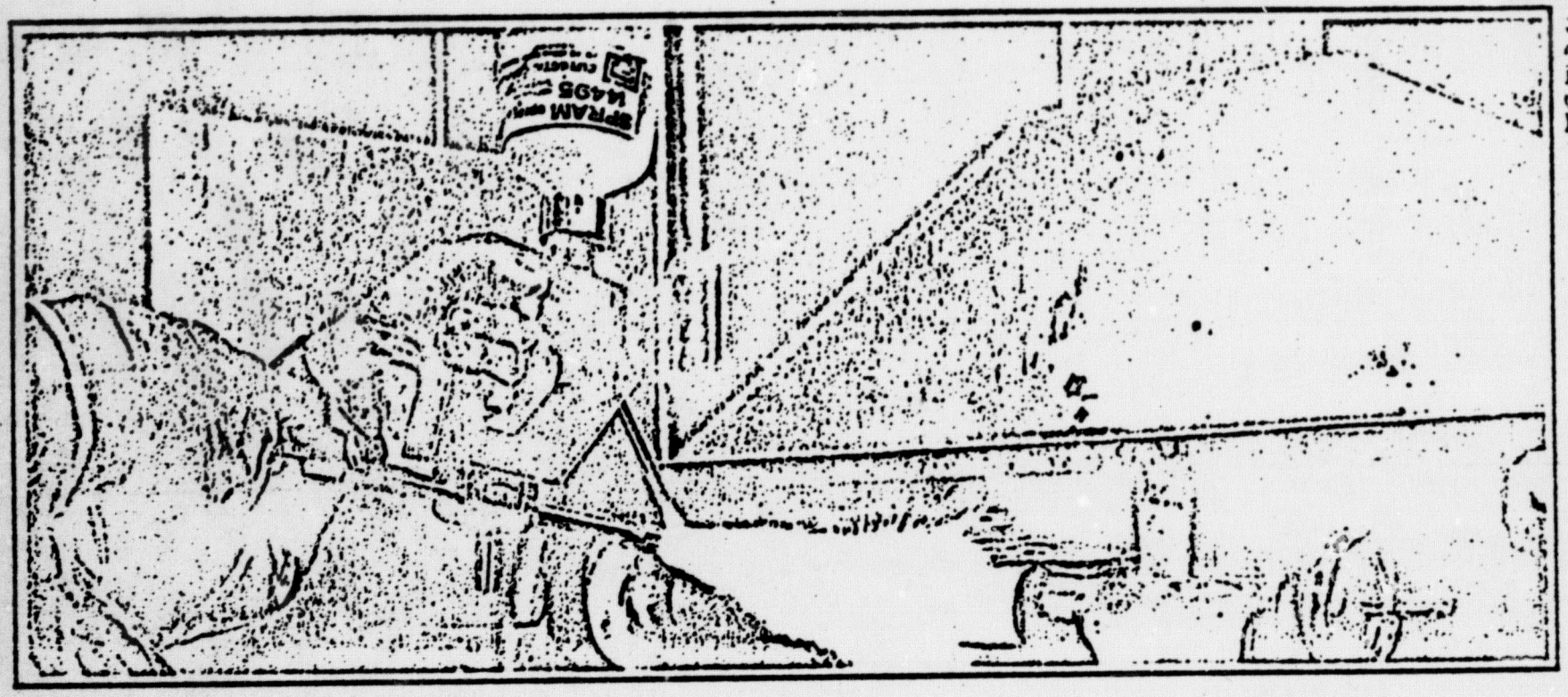
FOR USE ON THE FOLLOWING BASE METALS
Ferrous Metals • Cast Iron • Nickel Alloys • Stainless Steels • Copper Alloys
DEPOSIT EFFICIENCY Over 90%
RECOMMENDED COATING THICKNESS Between 0.004" and 0.008"

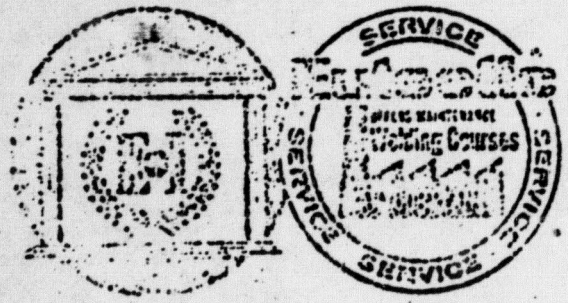
FINAL COATS

DIAMAX 19112 is the first carbide containing alloy powder successfully adapted for wide gap metal spray application. Deposits feature a saturated dispersion of ultra-bond micro-crystalline platelets which provide an unprecedented degree of abrasion and frictional wear resistance. Deposits can be ground to a smooth, low-friction finish or returned to service in the "as-sprayed" condition to utilize the inherent gripping action.

DIAMAX 19112 is specifically designed for bearing applications where severe abrasion is present and where the pressure of carbides will not tend to score the mating surface.

FOR USE ON THE FOLLOWING BASE METALS
Ferrous Metals • Cast Iron • Stainless Steels • Nickel Alloys • Copper Alloys
DEPOSIT EFFICIENCY Over 90%
MACHINABILITY Finish by grinding.





Eutectic Institute for the Advancement of Maintenance and Repair Welding Techniques

40-40 172nd Street, Flushing, New York 11358

General Machine Shop

Shaft bearing area fits, grease seal areas, gear fit areas

Power house pumps, sleeves, shafts

Power house coal crushing shafts, pumps, steam engine valves, and pistons, throttle steam valve stems, coal pushing augers and stubs

Petroleum

Pump plungers and pistons
Pump sleeves, wear rings
Wash pipes, mud pump
Pump heads and casings
Pump shafts
Pump bushings
Pump impellers

Spram ExoTec: . Dynamic New Eutectic Product

Spram ExoTec custom metal alloys are exothermic Self-Bonding spray powders which become pyrogenic when introduced to the flame of the Spram Gun. A reaction takes place during spraying which generates a high temperature to the powder particles so that when striking the work piece, a diffusion effect with the base metal occurs. The interaction effect at the surface of the base metal provides a very high bond strength. This surface becomes the best possible building block for the next step of the process, applying non-fused buildup overlays.

After applying a bond coat of ExoTec Alloy, switch to a module of the proper type Eutectic Spram custom alloy and then continue to overlay the work surface area until buildup is complete.

The Spram Gun makes conventional metallizing take on a new dimension – without the necessity for complicated accessories, or sensitive adjustments.

THE SPRAM PROCESS
DATA SHEET NO. 24904

SPRAM EXOTEC 24904
A PYROGENIC SELF-BONDING POWDER

SPRAM ExoTec 24904 is a reliable, strong bonding surface and building block for overcoating or metallizing with specially matched alloys. The combination of the SPRAM Gun and ExoTec 24904 gives deposit speed rates which are an exclusive Eutectic first—a breakthrough in powder technology!

When non-fused coatings are applied through the SPRAM Gun, SPRAM ExoTec 24904 should always be used as the first pass to insure highest bond strength to the base metal.

SPRAM ExoTec 24904, when introduced into a flame, reacts exothermicly imparting much higher temperatures to the powder particles than the flame alone can provide. The flame triggers the pyrogenic reaction and propels the individually heated particles onto the work surface. Superheated particles bond to the work surface through an individual contact.

Because bonding heat is generated in the powder itself, and not through the base metal, there is no distortion, and the work piece remains relatively cool. Result—Fast, strong surface bonding!

CHARACTERISTICS OF DEPOSIT

Coverage (Per 1400 Gram Module)* ..... 2.060 Sq. In. at a thickness of .005"
Deposit Rate ..... Up to 14 lbs. per hour
Deposit Efficiency* ..... Excellent (90%)
Recommended Coating Thickness ..... .004 to .006" thickness for bond coatings
Type of Application ..... Provides a high bond coat under non-fused coatings.
Base Metals .... Most common ferrous metals, nickel alloys, stainless steels. The only type of bonding powder applicable to hardened base metals.

* Surface coverage data and deposit efficiency are determined by laboratory tests under optimum spraying conditions.

FEATURES

SELF-BONDING
Best possible tensile strength to the base metal for non-fused coatings. Insures a high integrity to the build-up surfaces. The only powder type for bond coats on hardened base metals.

FAST SET UP
The undercoat of ExoTec and the overcoat alloy are sprayed with the same SPRAM Gun. Excellent for large or difficult shapes where elaborate base metal preparation is impractical.

HIGH DEPOSITION RATE
Deposit up to 14 lbs. an hour with the SPRAM Gun. No other bonding material can match this speed.

ONE-STEP OPERATION
ExoTec Powder is sprayed on—no fusing stage is involved—it bonds on impact.

SPEEDS OVERCOATING
.004 to .006" undercoat of SPRAM ExoTec 24904 is the preferred surface for many overcoating alloys.

LEADER IN RESEARCH
LEADER IN SERVICE
EUTECTIC
WORLD LEADER
MANUFACTURING IN 37 COUNTRIES
SERVICE IN 114 COUNTRIES

EUTECTIC CORPORATION
40-40 172nd Street, Flushing, New York 11358

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THE SPRAM PROCESS DATA SHEET NO. 24904

COMPOSITION AND FORM

A composite special formula powder with controlled particle size distribution (sieve analysis) to enhance the pyrogenic effect. Carefully controlled, specially formulated for optimum deposit efficiency and high deposit rates with SPRAM Gun.

PACKAGING

1400 Grams per module. The exclusive module is designed to protect the integrity of the powder and also allow convenient cartridge loading on the SPRAM Gun.

CHEMICAL AIDS

EUTECTO-MASK® and EUTECTO-SHIELD are designed to protect finished surfaces from adherence of SPRAM particles. These compounds should be used to protect keyways, threads and other surfaces during spraying and fusing.

WORK SURFACE PREPARATION

Surfaces to be overlayed should be prepared in accordance with instructions detailed in the SPRAM Process Manual.

SPRAM alloys can be overlayed on top of surfaces first coated with SPRAM ExoTec 24904 Pyrogenic Self Bonding powder. This procedure can be used where surface requirements, or size of the part, is a consideration or when hardened parts must be surfaced.

APPLICATION

Preheat work surface with SPRAM Gun flame at 200°F to evaporate surface moisture. With SPRAM Gun about 6" to 10" from work surface begin spraying. Apply an even coat depth of .004 to .006". Maintain tip-to-work surface distance to insure optimum bond strength. No fusing step is required.

OVERCOATING

Select the SPRAM Custom Metal Alloy desired. Immediately after depositing an undercoat of SPRAM ExoTec 24904, apply the selected SPRAM Alloy to the depth desired. Overlays are typically placed into service after surface finishing. Hard overcoats are finished by grinding; softer overcoats by machining. Some specialized applications may permit use of as-sprayed, unfinished overcoat surfaces.

INDUSTRIAL USES

Journals
Shafts subject to moderate to low surface shear
Bearing fits
Crank shafts
Mandrils

Consult your Eutectic Institute Representative

EUTECTIC INSTITUTE FOR THE
ADVANCEMENT OF MAINTENANCE AND
REPAIR WELDING TECHNIQUES
40-40 172nd Street, Flushing, New York 11358

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Save down time...repairing costly parts with the superior flame spray fusion bonding process that achieves METALLURGICALLY ENGINEERED WEAR SURFACES.

Another FIRST From Eutectic...

SPRAM

DX
FD

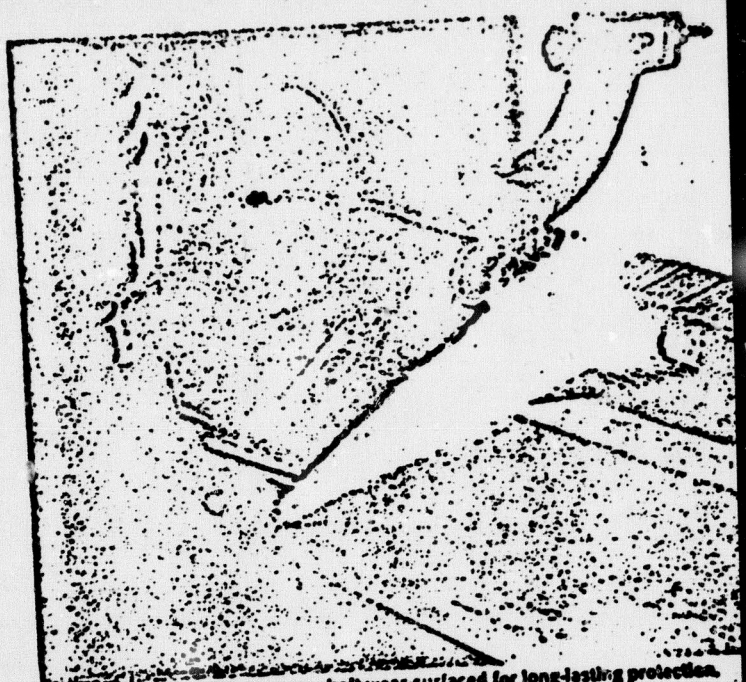
EUTECTIC INSTITUTE FOR THE ADVANCEMENT OF MAINTENANCE AND REPAIR WELDING TECHNIQUES

5369

The SPRAM Process

Spram metal spraying is a system which utilizes a torch flame to heat and propel specially formulated Eutectic Spram alloy powders to produce faster, smoother overlays that can be controlled to closer finished dimensions than any other method on the market today. Deposits are dense, sound and without inclusions or porosity, and frequently require no finish machining.

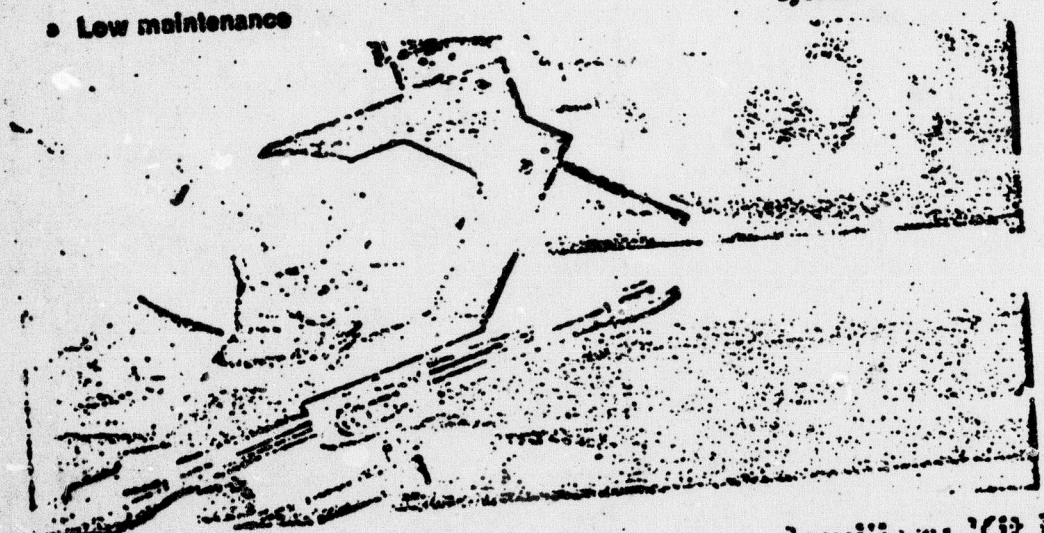
Through the simple operation of spraying and fusing, the Spram Process produces metallurgically bonded surfaces of superior deposit integrity with a hardness range of RC 25 to RC 61. Spraying and fusing are easily performed and can be done without changing tips or gas pressure settings. There is no compressed air, no flowmeters, no vibrators! No aspirators to clog.



Stainless steal centrifugal pump shaft wear-surfaced for long-lasting protection.
SAVED: $1[illegible].00

Features:

- A precision process, yet simple and free of complications.
- Torch deposit rate exceeds 14 lbs./hr.
- Lightweight, durable construction
- Deposit hardnesses range from RC 25 to RC 61.
- Ease of operation
- Low maintenance
- No compressed air, no flowmeters, no vibrators!
- No aspirators to clog!
- Low cost
- Process equipment matched to custom Spram powders
- Module containers feed powder to oxy-acetylene flame, providing fool-proof gravity feed delivery system.



[illegible]ram Gun:

The exclusive Spram Gun is a rugged heavy duty torch and Powder Feed assembly specially designed to heat and propel the Eutectic Spram alloy powders onto a work piece for overlaying or building up. Can be hand-held or mounted on a lathe for automatic traversing.

Auxiliary Kit L:

(including #4 torch tip assembly and manifold ing components): Provides greater heat inpu for fusing larger diameters or massive parts.

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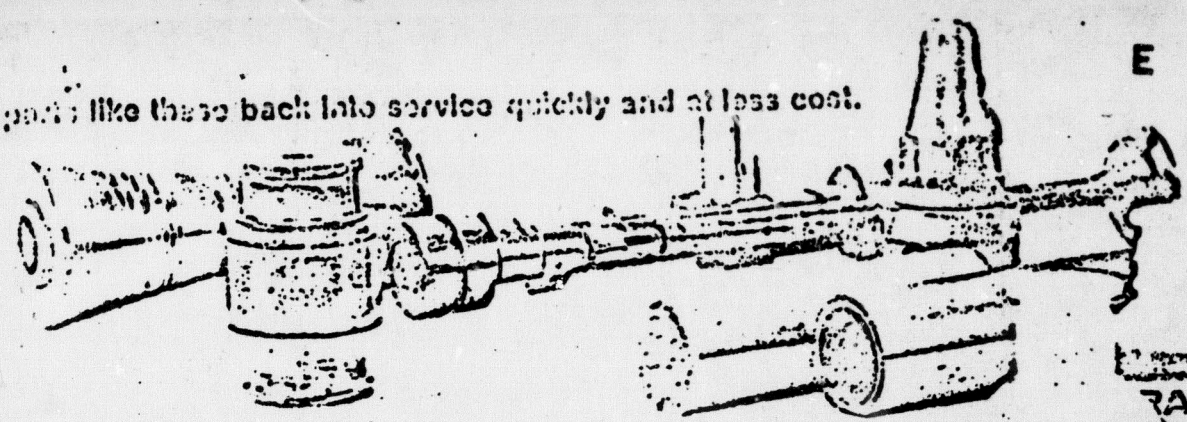
...l parts like these back into service quickly and at less cost.



SPRAM Custom Metal Alloy Powders:

The Spram custom metal alloy powders were specially developed for a wide variety of applications. They have high wear and oxidation resistance and corrosion resistance that compares favorably to premium stainless steels. They will usually outwear their equivalent hardness in steel alloys many times.

SPRAM custom metal alloy 14496 (RC 58-61)
...s generally used when excellent wear resistance is required. The low coefficient of friction of this alloy provides exceptional performance when used on pump parts which work against a packing, or seal, or on sliding metal surfaces. It has excellent resistance to high stress abrasion and resists scouring action.

SPRAM custom metal alloy 11495 (RC 47-52)
...s an intermediate hardness alloy and is frequently used where finishing is a problem, or where finishing by machining with carbide tools is required. It exhibits superior wear resistance, and is similar to 14496 in all other respects.

SPRAM custom metal alloy 14494 (RC 35-40)
...s a good choice when both good machinability and wear resistance is required, or when a buildup repair is necessary.

SPRAM custom metal alloy 14493 (RC 25-30)
Fulfills the requirements where the best machinability is required so that the deposit can be quickly finish machined. It is a favorite alloy when buildup of metal is required on repair areas and for metallized coating applications. Bearing fits and seal areas are ideal applications. It can be fused to the base metal or used in the as-sprayed condition.

SPRAM custom metal alloy 14112
(RC-Carbide Range)
Is used where extreme wear resistance is required and should be finished by special grinding wheels. Contains tungsten carbide.

Alloy steel tube-forming roll shaft repaired, with no costly finishing required.
SAVED: $110.00!

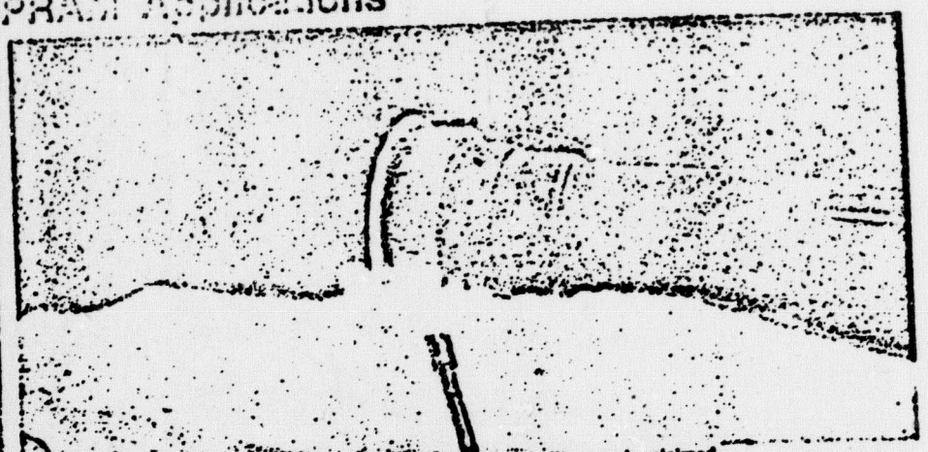
SPRAM ExoTec Pyrogenic Self-Bonding Powders:

With SPRAM ExoTec Powders it is now possible to overlay or metallize large surfaces with less rigorous base metal preparation. ExoTec is a family of pyrogenic self-bonding powders which become exothermic when introduced into a flame, generating additional heat to the powder particles and producing exceptionally high bond strengths.

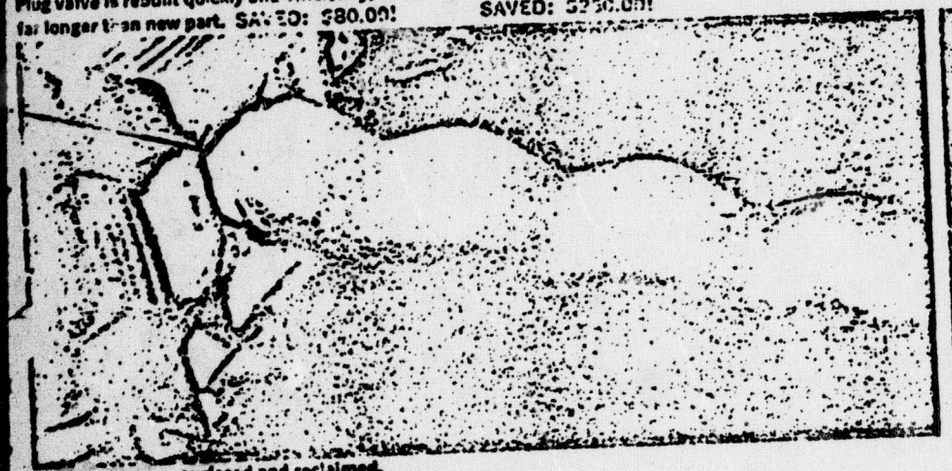
Because bonding heat is generated in the powder itself, and not through the base metal, there is no distortion and the workpiece remains relatively cool. (Coatings are not fused.) For example, SPRAM ExoTec Powder 24904 is always used as an undercoat for overlays. Frequently SPRAM ExoTec 24904 is used as a bonding coat for SPRAM Alloy 14493 or SPRAM Alloy 14494, when they are to be used in the as-sprayed condition.

Typical Cost Saving OSPRAM Applications

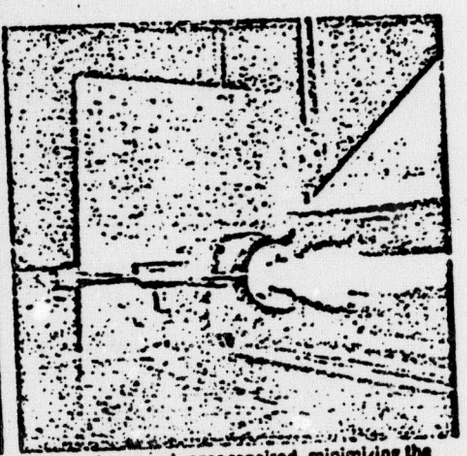
Plug valve is rebuilt quickly and efficiently, and lasts far longer than new part. SAVED: $80.00!



Reduction gear box shaft from transmission of prime mover, built up and reclaimed. SAVED: $230.00!



Pump rotor wear-surfaced and reclaimed. SAVED: $120.00!



Alloy steel pump plunger repaired, minimizing the need for spare part inventory. SAVED: $80.00!

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ADDITIONAL LITERATURE

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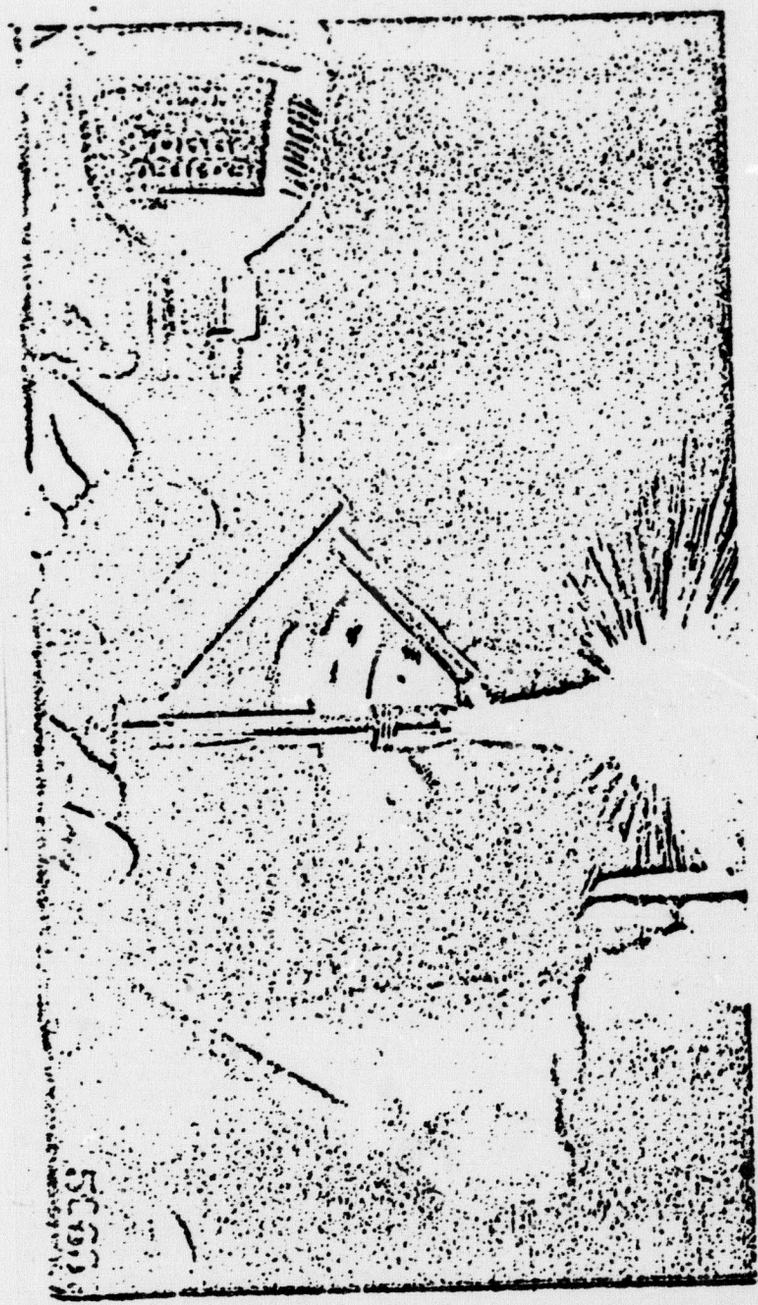

The RoToTec Process

A Handbook For Users

EUTECTIC+CASTOLIN INSTITUTE
FOR THE ADVANCEMENT OF MAINTENANCE AND REPAIR WELDING TECHNIQUES
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Foreword—Getting the Most Out of Maintenance...

The RoToTec Process represents a truly profound advance in maintenance and repair capability . . . from two standpoints:

1) **The wide range of applications for which it is suited . . .**
2) **The wide range of personnel who will enjoy its simplicity.**

The primary feature of the RoToTec Process, the feature which gives it its uniqueness—is the fact that the workpiece or part to be repaired *need* never be brought up to temperatures—even approximating—those associated with other methods of flame-spray coating. In effect, this means that the RoToTec Process is a "cold process". It is the key factor to RoToTec's simplicity, efficiency, speed and *RELIABILITY*. Because it *eliminates* the need for *high-heat input* to the part, it also avoids the drawbacks, problems and deficiencies of every other repair method which depends on heating the workpiece to a red hot state.

No single component of the RoToTec Process can be separated from the "total" process. They were all designed together, to work together. The RoToTec Gun, the RoToTec Powders and the techniques developed for preparing and RoTo-Coating the work surface are all vital to the success of the final result. Each phase, each step, each piece of equipment, each powder composition has been designed to contribute a specific feature, has been engineered to fulfill a specific function. Thus, the RoToTec Process is greater than the sum of all its parts.

It is no accident that the new capability afforded to maintenance men and metal-working specialists by the RoToTec Process was developed by the Eutectic Corporation. For over 60 years, Eutectic has made a policy of unceasing effort to uncover new and better ways to do the job; to expand the frontiers of theoretical knowledge and practical know-how in the special field of metal repair and restoration. The Company's excellence in providing industry with the widest variety of materials and processes for repairing worn, broken, cracked and mismachined parts remains unchallenged. No other organization has a comparable diversity of interest or experience in so many areas of metal part repair. On every metal, on every metal shape, on every combination of service condition. This is our heritage . . . and our continuing challenge.

Every achievement made by Eutectic has been predicated on the understanding of one basic fact: LOW HEAT INPUT TO THE BASE METAL MINIMIZES DISTORTION, WARPING AND CHANGES IN

THE BASE METAL. No matter what the process or application—the less heat transmitted to the workpiece, the better the result.

RoToTec is the ultimate in Low Heat Input! It is your assurance of better results on every applicable part repaired by the method. We are proud to offer it to you.

How to Use This Handbook

For the most profitable use of the RoToTec Process, it is suggested that each operator who will have occasion to use the equipment in repairing worn parts familiarize himself with a preliminary knowledge of what the process and procedures are all about. It is advisable, therefore, that the maximum number of employees read this manual completely, at least once, to gain fundamental understanding about the process, the equipment and the nature of RoTo-Coating. It is also helpful to know what information this handbook contains, so that, in the future he will know where to turn for answers to specific questions dealt with in the following pages.

It is the hope and purpose of this handbook to provide the user with the answers to practical questions: *When* to use the RoToTec Process; *why* to use it; and, of course, *how* to use it.

To the extent that we succeed in answering the above questions . . . to that extent have we succeeded in fulfilling the purpose of this Manual.

Good RoTo-Coating!

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SECTION I—General Discussion

The RoToTec Process refers to the complete process whereby new metal is reliably added to a cylindrical surface of a metal "workpiece" or part. The basic equipment and materials required are:

1—Standard oxygen and acetylene fuel supply (3/16" hoses) including set of accurate regulators*

2—• RoToTec Gun
- EXOTEC 29904 powder (bond coat)
- Variety of RoToTec Powders for final coats.
- Eutectic Solution #103 (Protective Shielding Compound)

3—A lathe with a swing big enough to accommodate the workpiece.

4—Standard 90° carbide-tipped cutting tool for all machining.

5—Grinder or grinding attachment for finishing the harder coatings. (Required only for RoToTec 19910).

6—Degreasing solvent for cleaning workpiece.

That's all you need to get professional RoToTec repairs.

**Eutectic TRI-SAFE Monitors are recommended.*

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RoToTec . . . THE "COLD PROCESS" . . .

The fact that the workpiece requires only minimal heat . . . that during actual RoTo-Coating, it is usually well below 500°F. (well below the temperature at which discoloration takes place) . . . means that the RoToTec Process of adding new metal is essentially a "cold process".

REMEMBER! IF "HEAT TINTING" OR DISCOLORATION OCCURS, THE WORKPIECE IS BEING UNNECESSARILY HEATED AND IMPROPERLY ROTO-COATED.

WHEN TO USE RoToTec . . .

The RoToTec Process was developed with a particular end-use in view. Although there are countless applications for which the process is recommended, it should be understood that the type of parts suitable for RoTo-Coating consist only of those which:

1) Can be rotated at proper speeds. (See Page 8)

2) Require repair on areas which are cylindrical in shape and which wear in service due to a uniformly-applied load.

The above qualifications, although *seemingly* limiting actually represents an extraordinary range of applications. It consists of a wide category of shafts, journals, rolls and bearings. For applications which coincide with the type of wear, motion and service conditions discussed, the RoToTec Process is ideal because . . .

IT SLASHES DOWNTIME!

IT REDUCES THE NEED FOR COSTLY SPARE PARTS INVENTORIES!

IT ELIMINATES COSTLY REPLACEMENT AND EXPENSIVE METHODS OF REPAIR!

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WHY USE RoToTec...

The bearing surfaces of many shafts wear precisely due to metal-to-metal contact in rotating motion. They produce similar "bands" or "ring" patterns of wear. Areas, such as bearing seats, press fits, seal and packing areas must be recognized as "critical" areas because they demand urgent attention. When the degree of wear becomes so extreme as to produce a fit that is too loose or a situation where leakage occurs in seal areas . . . continued use of the part involves profound risk of complete breakdown. With RoToTec as part of any shop's arsenal of repair methods, the proper attention can be given to such problems . . . when and where it is needed, with unmatched *reliability*.

SELECTING THE RIGHT "FINAL COAT" POWDER...

All RoToTec repairs must initially start with a bond coat (EXOTEC 29904). Choice of final coat powder is determined by the specific part and the service conditions under which it will function.

For most repairs, RoToTec 19985 is recommended. It yields a hard, general-purpose coating that is machinable and provides superior overall wear-resistant qualities.

For applications where the original part would perform better and last longer with *harder* bearing surfaces —and if grinding equipment is available—RoToTec 19910 is suggested.

Finally, for applications where superior bronze-type bearing surfaces with outstanding machinability and low-friction features are desired, use RoToTec 19850 for the final coat.

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SECTION II—Procedure

SEQUENCE OF STEPS:

A) Preparation

B) Roto-Coating

C) Finishing

In the following pages, details of each step are presented. Although this handbook attempts to convey *what* to do, wherever possible, reasons are also given as to *why* a certain procedure or technique is recommended. Experience has shown that where an operator understands *why* he does something, he inevitably *does* it . . . and does it *better*.

A—PREPARATION

PREPARING THE WORKPIECE

It is imperative that Roto-Tec coatings bond to *clean, uncontaminated* and *dry* metal surfaces. The presence of even a slightly oily fingerprint may destroy the integrity of a repair, necessitating its being stripped off completely and restarting.

1—DEGREASING

Using a commercial solvent, clean and degrease the worn section. Scrub with a clean, stiff brush. Cleaned area should include worn section and generous portions of adjacent areas.

Note On Porous Base Metals:

Porous metals (such as cast iron) have a tendency to absorb contaminants such as oil and grease from prior use. Before degreasing, these impurities must be burned out. Mere solvent-cleaning will not be sufficient.

For porous metals, set up the workpiece so it can conveniently be heated with a torch flame. When heated, the ingrained grease will burn and give off a dark smoke. (Use proper ventilation!) Continue burning until smoking stops. Brush off any char. Finish degreasing as described above.

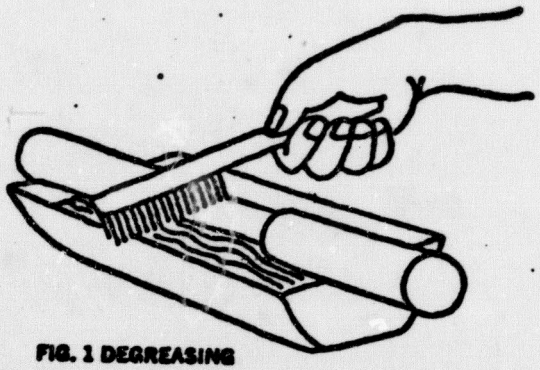

FIG. 1 DEGREASING

2—PROTECTING THE LATHE

Cover the lathe bed (ways) with a sheet of asbestos or other non-flammable material. Protect all other exposed sections of lathe with coating of oil. (With experience, each operator will learn to control the spray pattern, and in time only a minimal portion of the lathe will require protection. In the beginning, however, it would be wise to exercise more caution rather than less.)

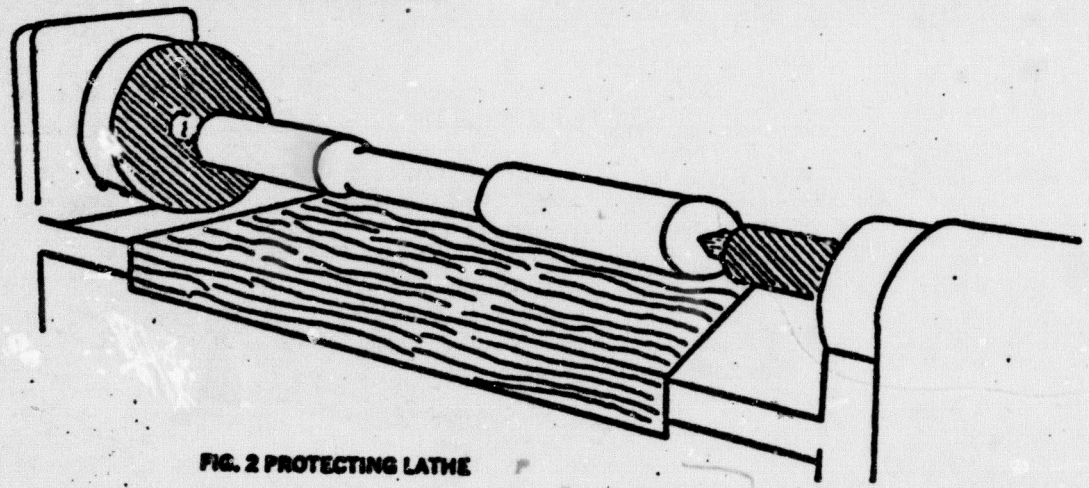

FIG. 2 PROTECTING LATHE

3—SETTING UP PIECE IN LATHE

Where possible, set up the part between centers. Otherwise, chuck the part so that it is held securely and the area to be worked on is accessible for all subsequent machining and RoTo-Coating. To avoid contamination of previously degreased surface areas, do *not* touch area to be repaired with bare hands when handling.

Part should run as true as possible. The truer the part rotates, the better the final result.

4—SPEED

The RPM at which the workpiece rotates depends on the diameter of the worn area. The following chart shows recommended speeds for parts where coating area is under 10" in diameter. They are to be used during the following steps:

• Preheating • RoTo-Coating (Bond and Final coat); • Finishing.

Diameter of worn area	Recommended turning speed (RPM)*
Up to 1½"	250
1½"–3"	150
3"–6"	75
6"–10"	50

Notice:

The larger the diameter, the lower the RPM required to achieve approximately equivalent surface speeds.

**The RPM recommended is based on producing a surface speed range of 50-125 surface feet per minute.*

5—MASKING THE AREAS NOT TO BE COATED

Each RoToTec Intro Kit contains a can of Eutectic Solution No. 103. It is designed to shield metal surfaces adjacent to the worn area.

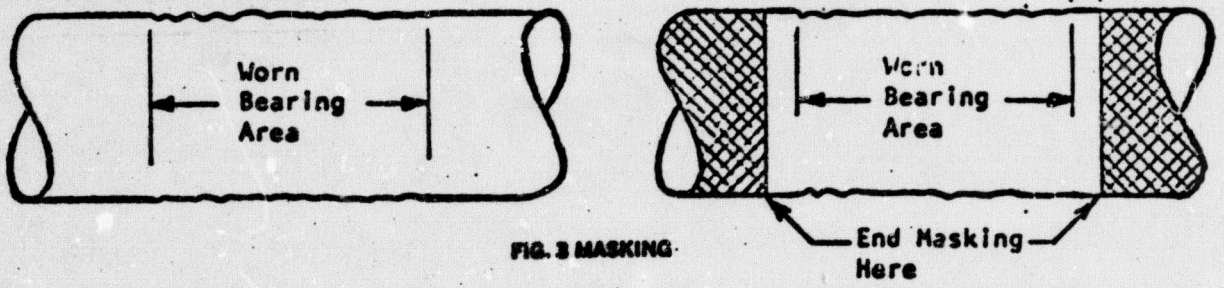

FIG. 3 MASKING

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With the part turning, use a small brush and dip into the masking solution. Starting about 3" from the end of the bearing area, hold the brush on the underside of the rotating part and start applying a *thin* coat of masking solution.

Work brush in, toward the bearing surface, stopping about ¼" to ½" from the edge of the bearing surface. Repeat for opposite side. Use the masking solution sparingly. Only a thin coat is necessary.

Mask any holes, slots or keyways separately, while part is at rest. Allow masking solution to dry thoroughly.

6—UNDERCUTTING WORN AREA

Undercutting is absolutely necessary. It serves the following functions:

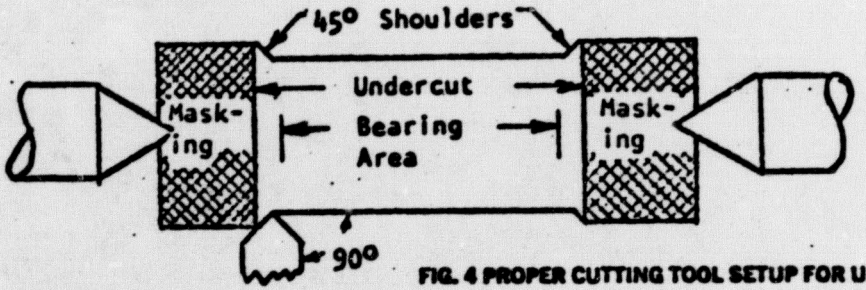

FIG. 4 PROPER CUTTING TOOL SETUP FOR UNDERCOATING

a) It produces a uniform cylindrical surface for the subsequent build-up.

b) It removes the skin of questionable metal (oxides and scale) from the surface which may be unsuitable as a bonding surface.

c) It provides greater depth to the repair, thus assuring longer-lasting coating performance.

The *length* of the undercut should extend about ½" on either side of the bearing area . . . to coincide with the edge of the masking solution. The reason for this is to assure that the entire bearing surface is completely rebuilt of only *one* material with *one* coefficient of friction. The bearing area can usually be determined by the shiny appearance of the surface (burnished during the metal-to-metal contact while in service). If a bearing surface is *not* well defined by a shiny area the exact limits of the bearing-area should be verified by measuring—where possible—the position of the mating bearing in relation to the part. Scribe a line on the workpiece to mark the boundaries of the bearing area.

DEPTH OF UNDERCUT:

The depth of the undercut will depend partly on the severity of the wear in the bearing area. *The minimum depth of the undercut, however, should be about 0.030" ON THE DIAMETER FOR FERROUS METALS AND 0.060" ON THE DIAMETER FOR BRONZES.*

REMEMBER! DO NOT USE COOLANT OR CUTTING COMPOUND FOR UNDERCUTTING OR THREADING.

All shoulders are bevelled 45°. Sharp inside corners should be avoided to insure proper angle of incidence of powder spray.

Correct 45° angles are automatically produced by the 90° cutting tool when used at right angle to workpiece as shown in Fig. 4.

For bearing areas at end of shaft, leave at least a 1/16" shoulder where possible (Fig. 5)

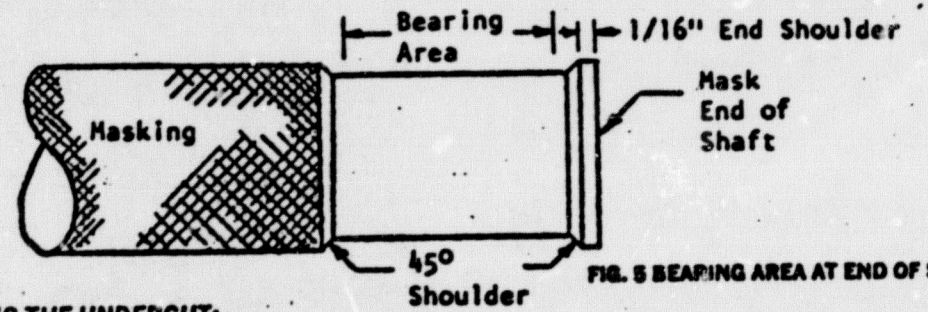

FIG. 5 BEARING AREA AT END OF SHAFT

7—THREADING THE UNDERCUT:

Threading the undercut area is essential. It is the fastest, most effective method for roughening the surface to be coated.

Threading serves to increase the surface area available for bonding between the base metal and the bond coat. It also modifies the buildup pattern of the sprayed coating in such a way as to significantly improve resistance to shear stresses when part is returned to service. Both factors contribute to the coatings superior reliability and performance.

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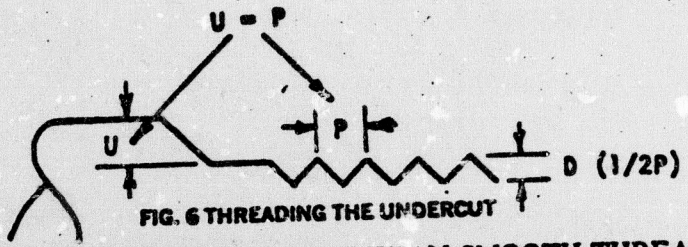

FIG. 6 THREADING THE UNDERCUT

ROUGH THREADS ARE MORE DESIRABLE THAN SMOOTH THREADS . . . AND they can be produced by positioning the tip of the tool bit slightly below the centerline of the shaft. Thread the undercut . . . according to the following rule:

Pitch of thread (P) = Depth of Undercut (U) on the radius

Number of threads per inch (N) = 1/P.
Depth of thread (D) = ½ P

EXAMPLE: A worn bearing area of a shaft requires an undercut of 0.030" (per radius).
Thus, U = 0.030"
Since U = P, the pitch of thread is also 0.030"
Since the number of threads per inch (N) = 1/P,
N = 1/0.030 = 33 (approximately)
and D = 0.015"

SOME OTHER TYPICAL EXAMPLES ARE SHOWN IN TABLE FORM:

Depth of Undercut (on radius)	Pitch	Depth of Thread	Threads Per inch
0.015"	0.015"	0.0075"	67
0.025	0.025	0.0125	40
0.040	0.040	0.020	25
0.050	0.050	0.025	20
0.060 (and above)	0.060	0.030	16

NOTE: Leave a slight land (about 1/16" between end of thread and end of undercut. (Fig. 7)

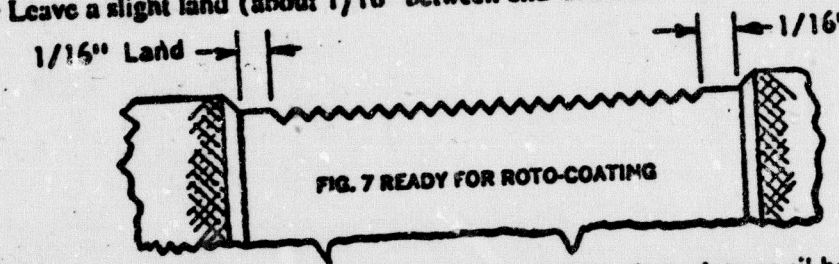

FIG. 7 READY FOR ROTO-COATING

Where threaded portion of bearing area includes keyways, flats, slots or oil holes . . . invariably burrs will be produced. They must be removed before RoTo-Coating. Chisel is recommended as the most practical and convenient method for removing burrs or flashing.

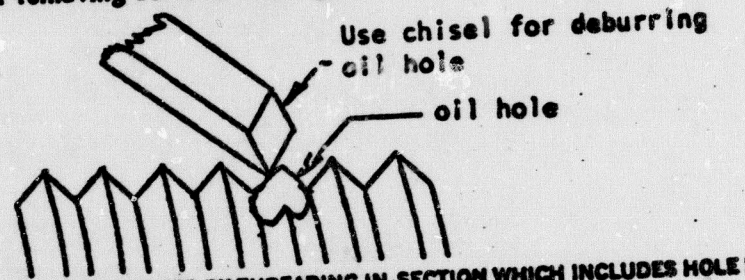

FIG. 8 CHISELING BURRS PRODUCED BY THREADING IN SECTION WHICH INCLUDES HOLE IN BEARING AREA.

OUTLINE REVIEW OF MACHINING STEPS PRIOR TO ROTO-COATING.

1–Let masking solution dry.
2–DO NOT USE CUTTING OILS.
3–Always use a clean, sharp, 90° carbide tool bit.
4–Undercut sufficient to clean worn area to uniform dimension. (0.015" *minimum on radius*; 0.030" for bronze.)
5–Thread the undercut.
6–Leave slight lands and shoulders as recommended.
7–All shoulders should be 45°.

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B—ROTO-COATING

1—*LIGHTING AND ADJUSTING THE RoToTec GUN FLAME*

When using 12-ft. lengths of 3/16" dia. oxyacetylene hose, set regulator valve pressures on fuel tanks as follows:

Acetylene:	4 - 5 lbs.
Oxygen:	8 - 10 lbs.

See special instructions on page 14 for RoToTec 19850 (Bronze)

Open acetylene valve on gun about ¼ turn and ignite.
Open oxygen valve on gun slightly.
Now, increase valve openings on gun alternately until full flame is achieved. Final flame should be ½X to 1X carburizing. (See Fig. 9)

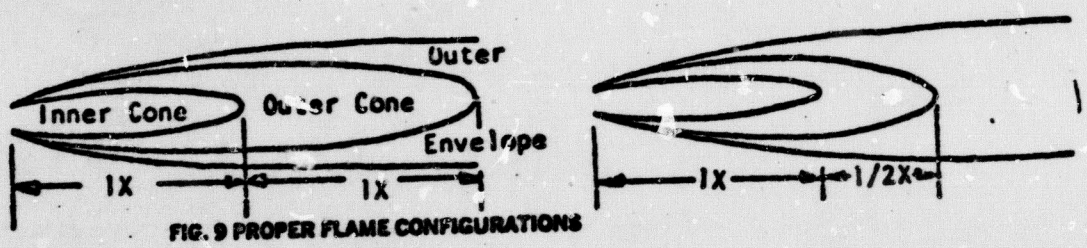

FIG. 9 PROPER FLAME CONFIGURATIONS

NOTE: If regulator pressures drop *more* than *1 lb.* after gun valves are open, adjust regulator valves to original readings.

Notice that the inner cone of the flame is surrounded by an outer cone *and* an outer envelope. The ideal length of the outer cone should be no larger than the length of the inner cone, nor smaller than half the length of the inner cone.

Once the above flame pattern is achieved, it need never be changed. However, it should be checked periodically and if the outer cone drifts to a condition of either too small or too large, readjust the appropriate valves (gun, regulator or both) to restore the proper flame.

SPECIAL INSTRUCTIONS FOR ROTO-COATING WITH RoToTec FINAL COAT POWDER 19850 (Aluminum-Bronze):

AFTER APPLYING EXOTEC 29904 . . . simply increase the *oxygen* setting on the regulator to 11-13 lbs. DO *NOT* CHANGE ACETYLENE SETTING!

RoToTec 19850 requires an *OXIDIZING* flame.

The proper oxidizing flame has the flame configuration as shown in Fig. 10.

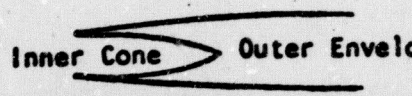

FIG. 10 OXIDIZING FLAME (For use only with RoToTec 19850)

Notice the disappearance of the outer cone and the simultaneous sharpening of the inner cone.

2--PRE-HEATING THE WORKPIECE

Before applying RoToTec Powders, two things must be accomplished; any surface moisture contained on the worn area must be driven off; and the part should be nominally warm enough to prevent uneven shrinkage stresses between the coating and the original metal of the part.

With the workpiece turning at recommended speed, preheat the work area to about 200°F.

FIG. 11 PRE-HEATING

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3 - SPRAYING THE THIN LAYER (.005") OF BOND COAT

With Powder Slide Valve in "OFF" position, turn the RoToTec Gun upside down (Spraypak receptacle at bottom) and insert Spraypak module of EXOTEC 29904 into the receptacle. Lock it into position with a half turn. Return Gun to normal position.

The position of the Gun for all RoTo-Coating is shown below.

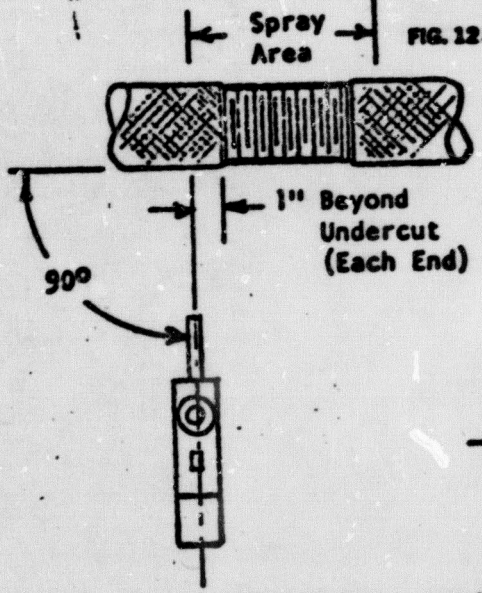

FIG. 12 GUN IN POSITION

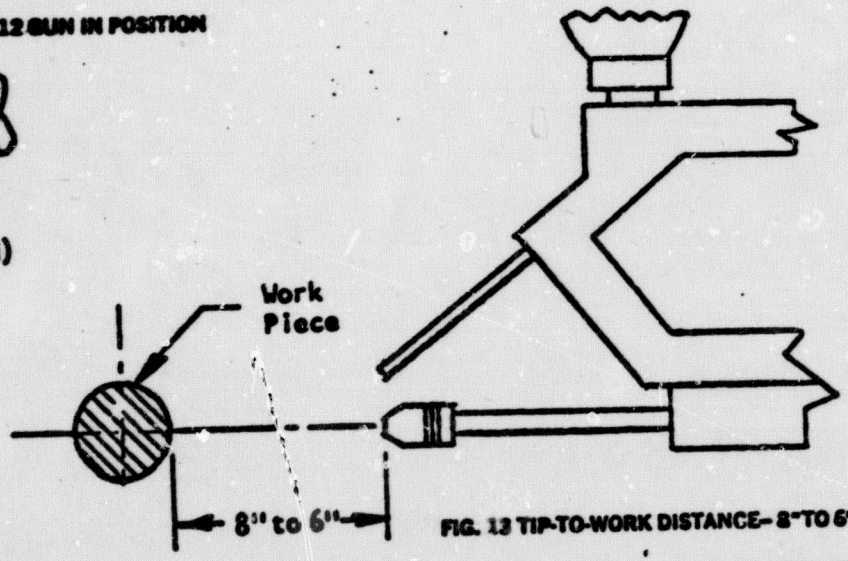

FIG. 13 TIP-TO-WORK DISTANCE– 8" TO 6"

Notice that the Gun is held square to the axis of the workpiece. Notice too, that the tip-to-work distance is 8" to 6".

With the Gun about 1" beyond the end of the undercut, (Fig. 12) slide the Powder Valve back. This releases powder into the flame. Start moving the Gun across the worn area, using a steady, even traverse. Maintain Gun at proper angle and distance as you make the traverse, ending up the pass about 1" beyond the opposite end of the undercut. (Where bearing area is at end of shaft, RoTo-Coat as far beyond the end of the undercut as possible without spraying the end of the shaft itself.)

REMEMBER! Only a thin (0.005") layer of EXOTEC is required. With a minimum of practice, the operator will easily be able to achieve this thickness with only one pass . . . adjusting the speed of the traverse to the diameter and turning speed of the shaft.

In general, the slower the turning speed, (rpm) the slower the traverse needed to achieve equivalent coating thicknesses.

The application of the bond coat should completely cover the bearing area . . . leaving no bare or "shiny" areas. Slide the Powder Valve forward to stop powder flow.

4—SPRAYING THE FINAL COAT

The actual thickness of the sprayed final coat should be sufficient to build up the complete surface of the bearing area to original dimension . . . *plus an excess* to allow for finish machining. The amount of excess, will usually depend on the size of the part (diameter, length of bearing area, etc.). In general, the larger the part, the more excess is recommended to assure that no slight variations during RoTo-Coating have left any areas with *less* than the minimum required for the required final dimension.

Replace EXOTEC 29904 with a Spraypak module of the desired final coat powder. Before RoTo Coating final coat, once again, make sure Gun Frame is horizontal, square to axis of workpiece and that the tip-to-work distance is 8" to 6". Open Powder Slide Valve, starting at one end of the bond coat. Work methodically. Do not interrupt RoTo-Coating operation *unnecessarily* for *extended* periods of time.

Use slow, steady passes. Once again, work gun beyond edges of bearing area before beginning return stroke.

Remember! During all phases of RoTo-Coating, the temperature of the workpiece should never rise to a point where discoloration of "heat tinting" occurs. If such discoloration occurs, stop for a minute and allow the part to cool while it rotates. Then, resume RoTo-Coating. Intermittent pauses will not harm the repair . . . and are recommended to help prevent overheating.

CONTINUE TO BUILD UP THE FINISH COAT UNTIL THE DIAMETER OF THE FINISH COAT IS ABOUT 0.020" IN EXCESS OF THE DIAMETER OF THE REQUIRED DIMENSION.

When buildup is completed, push Powder Slide Valve forward and turn off torch flame. Allow part to cool as it turns.

5—SEMI-AUTOMATIC SET-UP

All RoToTec Guns are equipped with a tool post mounting extension. Where practicable, RoTo-Coating may be performed by securing Gun in proper position and using appropriate automatic feeds . . . preferably for both forward and reverse passes.

OUTLINE REVIEW OF ROTO-COATING . . .

1—Light RoToTec Gun flame
2- Preheat shaft (200° F.)
3—Spray EXOTEC (0.005")
4—Spray final coat. Change flame settings only for RoToTec 19850 (Bronze) final coat.

C—FINISHING

1—MACHINABLE COATINGS

The following procedures have been developed with the specific aim of protecting RoToTec coatings from unnecessary failure. Each step has a reason. Any extra time and care exercised during the initial few repairs will be an investment in developing a "natural" feel for all future repairs . . . and assure the operator continued success.

FOR COATINGS ON SURFACES WHICH DO *NOT* INCLUDE FLATS, KEYWAYS, HOLES, ETC. . . .

The RoTo-Coated part—ready for machining—is illustrated in Fig. 14.

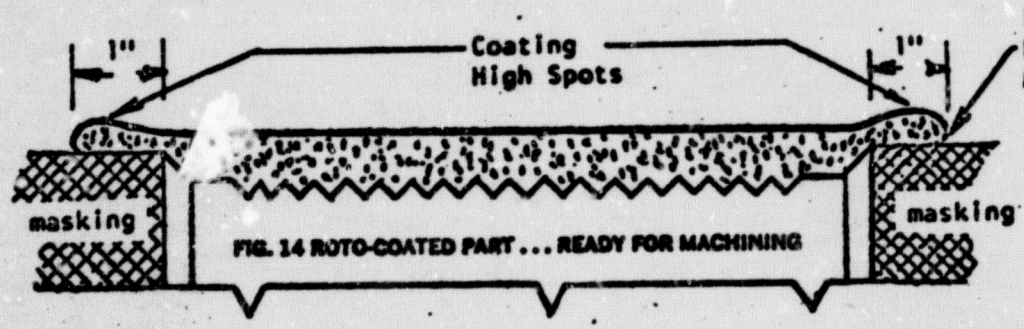

FIG. 14 ROTO-COATED PART . . . READY FOR MACHINING

First, set up cross feed for a 45° infeed, with tool as shown in Fig. 15.

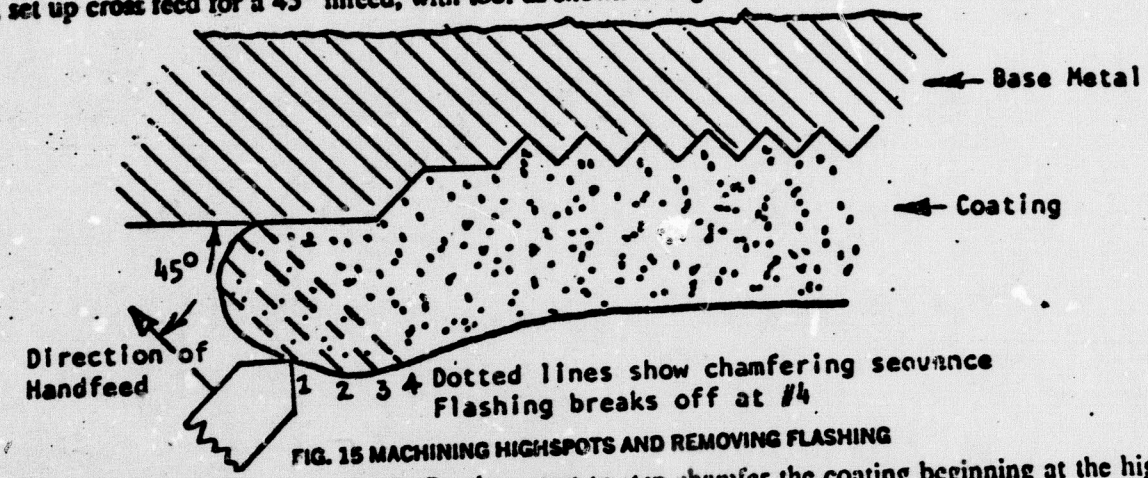

FIG. 15 MACHINING HIGHSPOTS AND REMOVING FLASHING

Using same turning speeds as for RoTo-Coating, start to step-chamfer the coating beginning at the high spot at one end. Feed in at 45° and traverse the cut by hand at 45° in the opposite direction. Continue to step chamfer the edge of the coating until the flashing breaks off. Reverse all angles and set up and repeat above procedure on the opposite end of coating. (Fig. 16)

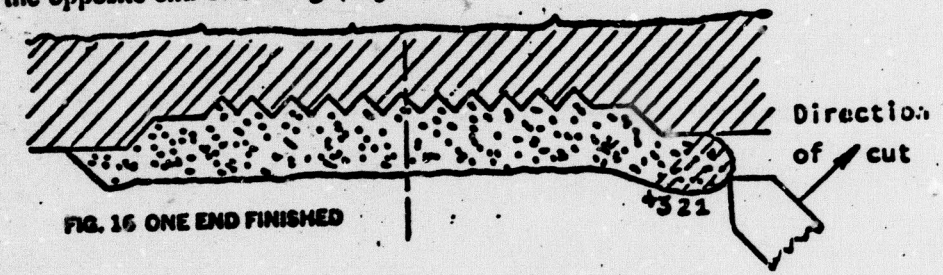

FIG. 16 ONE END FINISHED

With flashing removed at each end, set up tool *square* to workpiece and machine any remaining high spots at each end. Remove high spots by machining from the *inside* of the bearing surface toward the respective ends of the part. This prevents the tool from exerting any undesirable pressure against the coating. (Fig. 17)

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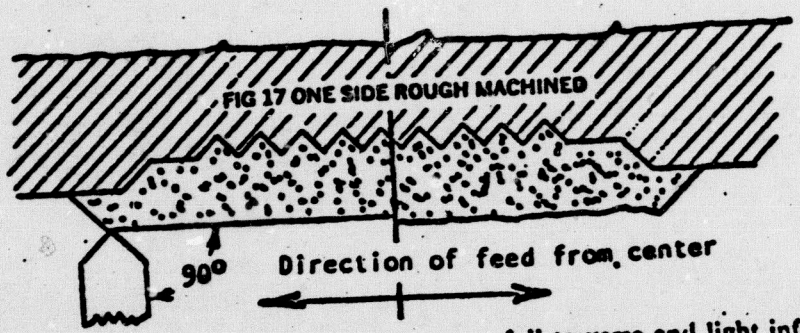

FIG 17 ONE SIDE ROUGH MACHINED

When the coating is of a fairly uniform thickness, use a full traverse and light infeed (maximum 0.005" on radius) and take a full longitudinal traverse cut. The final cut should be no more than a few thousandths.

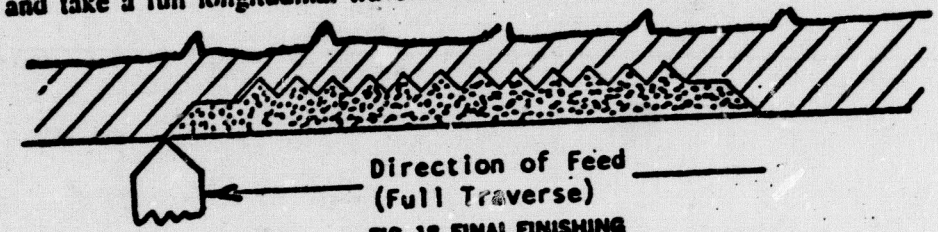

FIG. 18 FINAL FINISHING

FOR COATINGS AT END-OF-SHAFT . . .

Follow same procedures as for center-of-shaft bearing areas. After step-chamfering, the coating at the end of the shaft will look like this . . .

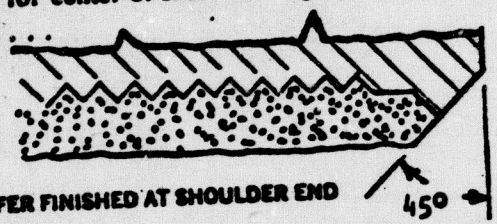

FIG. 19 CHAMFER FINISHED AT SHOULDER END

As before, remove high spots at both ends of coating, working each end away from center of coating. Take *final* cuts in *one* direction.

NOTE: **DURING ALL MACHINING OPERATIONS, TOOL BIT SHOULD BE CHECKED OFTEN. KEEP IT SHARP FOR BEST RESULTS!**

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FOR COATINGS WHICH INCLUDE FLATS, KEYWAYS, HOLES, ETC. . . .

Before machining, chamfer all edges and outside corner buildups of coatings on keyways, holes, slots, etc. with a file or hand grinder. If more convenient, remove part from lathe. The direction of the cutting stroke with the file should always be such as to exert *no* force which would tend to pull the coating away from the base metal. When grinding, the direction of the wheel should also conform to the above stipulations.

File or grind enough of a chamfer to expose the base metal as shown in illustrations below.

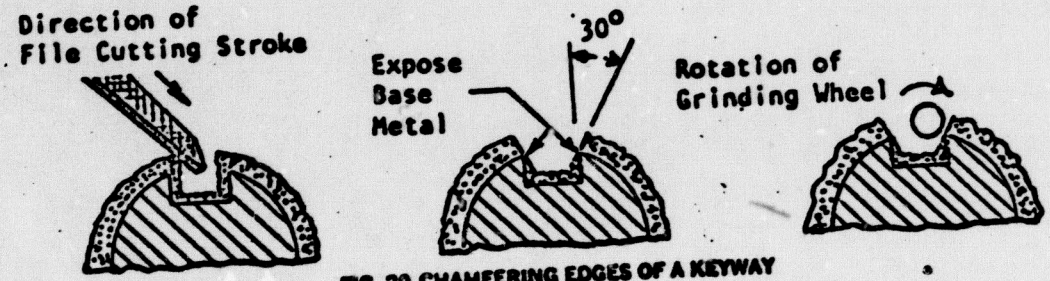

FIG. 20 CHAMFERING EDGES OF A KEYWAY

After all corners of the coating are chamfered, replace part in lathe and machine the coatings as described previously.

2—NON-MACHINABLE COATINGS

GRINDING:

Final coatings of RoToTec 19910 *must* be finished by *grinding*. Either cylindrical grinders or grinding attachments mounted in the lathe tool post may be used. Medium-hard silicone carbide wheels with a medium grit are recommended for grinding operations. Use speeds and feeds prescribed by the manufacturer for use on cast, brittle metals.

Before grinding, all edges and ends of coating must be chamfer-ground.

SECTION III—Maintenance of Your RoToTec Gun...

The basic component of the RoToTec Process is the RoToTec Gun. It is the most uncomplicated metallizing tool ever designed.

It requires an absolute minimum of maintenance. During RoTo-Coating there are no moving parts which are subject to wear, failure or breakdown.

There are three basic sections to the RoToTec Gun: The FORWARD FLAME ASSEMBLY; the FRAME; and the HANDLE.

To service any of the internal parts of the Frame, first remove the Frame from the torch by depressing the Release Button and sliding the sections apart. Notice the slight recess in the Slide Channel on the underside of the Frame. When replacing the two components, make sure that the Release Pin Screw snaps into this recess.

With the Frame disconnected, use the larger of the two Allen wrenches supplied (9/64") and unscrew the 4 Allen Head Assembly Screws which fasten the two halves of the Frame together. (The smaller, 1/16" Allen wrench is used for adjusting the Drop Tube and Module Receptacle.)

Should there be any reason to adjust the Powder Slide Valve . . . or other parts of the powder flow system, disassemble as described above and examine the Powder Slide Valve Assembly and/or the Rubber Valve Tube inside the Module Receptacle.

Check for dirt, grease or powder. If present remove Powder Slide Valve Assembly and clean with air gun, or wipe with a damp cloth and dry.

The Powder Slide Valve tension is factory pre-set and should normally require no further adjustment. To increase or decrease tension against the Powder Slide Valve, turn the Tension Screw Assembly with screwdriver.

"Click" stops serve to indicate both the ON and OFF position. In the forward "click" position, powder flow is OFF. In rear "click" position, powder flow is ON.

Slide Valve should *never* be under excess tension. It should slide easily with *minimum* thumb pressure.

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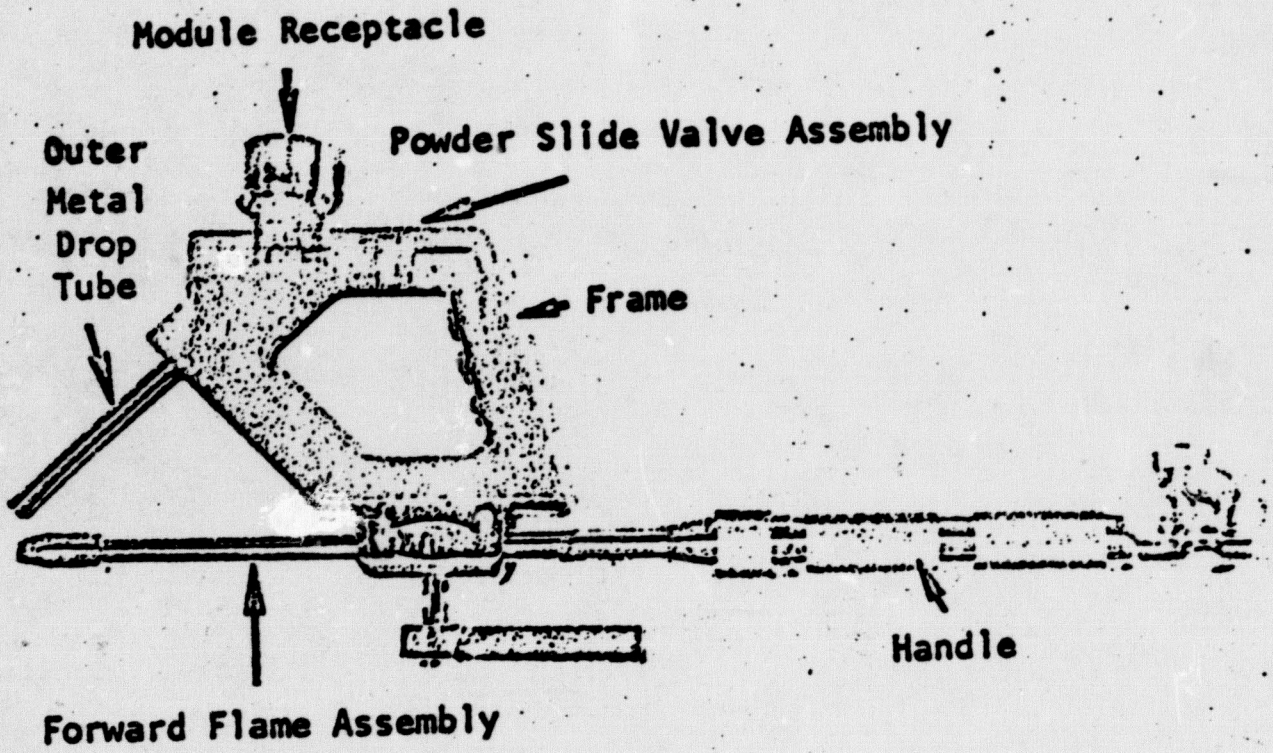

*NOTE: See parts list on Inside Back Cover.

If, after long usage, the Rubber Valve Tube loses its resiliency, or becomes damaged, replace it. It is easily removed and a replacement is easily pushed into position. Make sure when re-assembling Module Receptacle to Frame, that the Powder Slide Valve pin moves freely through the hole in the neck of the Receptacle to make contact with the Rubber Valve Tube.

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It is recommended that when the RoToTec Gun is not in use, the Slide Valve Assembly should be in the "open" position (to the rear). This will increase the life of the rubber and its efficiency.

THE POSITION OF THE OUTER METAL DROP TUBE . . .

The position of the Metal Drop Tube is factory set, and conforms to the dimensions and relationships shown below:

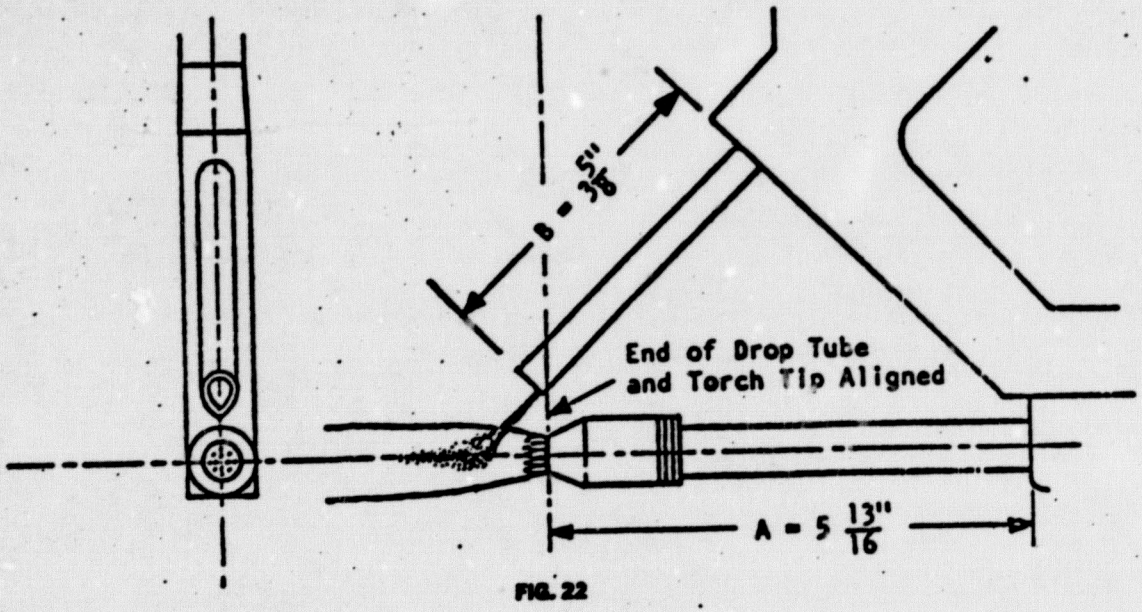

FIG. 22

In the event that dimension A or B of your RoToTec Gun requires repositioning to factory setting, proceed as follows:

Dimension A—Loosen the Tool Post Support Pin and slide Heating Tip and Tube Assembly to correct position. Tighten the Tool Post Pin.

Dimension B—Loosen the 1/16" Allen set screw in the Frame. Adjust Drop Tube and tighten.

"O" RING MAINTENANCE . . .

Occasionally, after long usage, the two "O" rubber rings within the Union Nu
ment. To do this, merely disengage the retaining ring from its groove, and
exposes the "O" rings. Remove the old ones, replace with new ones. Re
back and snapping the retaining ring into its groove.

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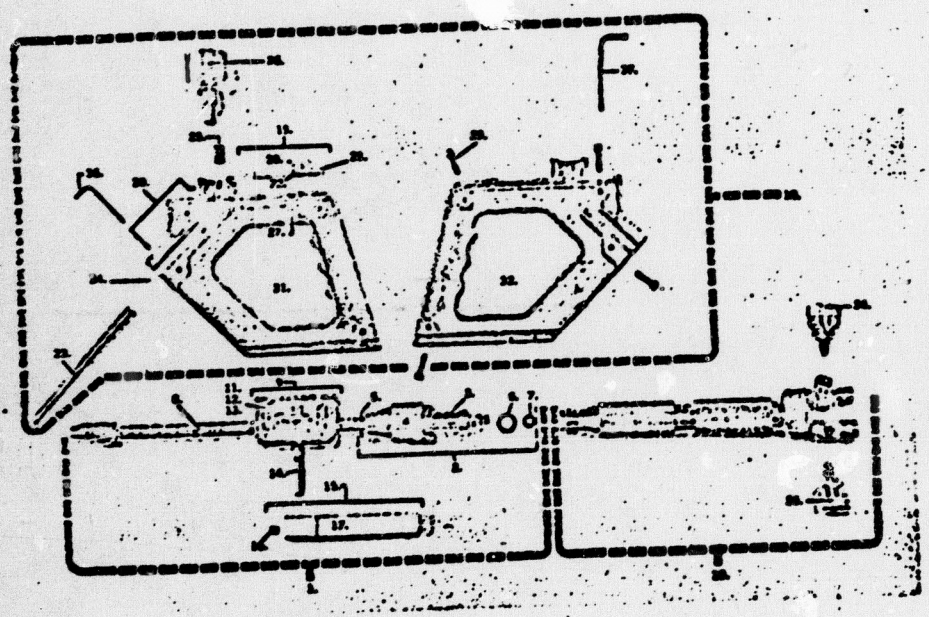
RoToTec Gun—Model I

Parts List



	DESCRIPTION	PART NO.
	RoToTec Extension Assembly	5104
1	Forward Flame Assembly (RoToTec)	5103
2	—Mixer Assembly	5025
3	Mixer	5026
4	Nut	5027
5	Retaining Ring	5028
6	Large "O" Ring Seal	5029
7	Small "O" Ring Seal	5031
8	—Heating Tip & Tube Assembly	5100
9	—Block Assembly	5032
10	Block	5016
11	Release Button	5014
12	Release Button Spring (not shown)	5015
13	Release Pin—Screw (not shown)	5051
14	Tool Post Support Pin	5022
15	—Tool Post Adapter Assembly	5039
16	Tool Post Adapter Set Screw	5052
17	Tool Post Adapter	5064
18	Powder Feed Frame Assembly (RoToTec)	5133
19	—Powder Slide Valve Assembly	5054
20	—Trigger	5041
21	—Valve Plate	5036
22	—Assembly Screw	5010
23	—Outer (Metal) Powder Drop Tube	5037
24	—Inner (Nylon) Powder Drop Tube	5040
25	—Rubber Valve Tube	5038
26	—Module Receptacle (RoToTec)	5102
27	—Tension Screw Assembly (Powder Slide Valve)	5105
28	—Name Plate (RoToTec)	5123
29	—Frame Assembly Screws (4)	5048
30	—Set Screws (2)	5049
31	—Right Half Frame Housing	5134
32	—Left Half Frame Housing	5135
33	Torch Handle Assembly	4101
34	—Oxygen Needle Valve Stem	4128
35	—Acetylene (Fuel) Needle Valve Stem	4129

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Construction and Earth Moving; Mining; Foundries; Railroads; Pulp & Paper; Steel Mills; Chemicals; Cement; Automotive; General Maintenance and Machine Shop; Petroleum; Sugar Mills.

MAJOR APPLICATIONS

Forming and Stamping Dies; Machine Overlays; Pattern Repairs; TIG—General; Silver Joining; Forging Dies; Gears.

OVERLAY APPLICATIONS

Buckets; Agriculture Implements; Crushers; Conveyors, Screws; Mixers, Scrapers; Valves; Hard Surfacing—General; Hard Surfacing—Severe Abrasion and Wear.

ADDITIONAL LITERATURE

Aluminum Repair; Bronze Repair; Cast Iron Repair; Copper Base Alloys Joining; Stainless Steel; Steel Joining (High Carbon & High Alloy); Steel Joining (Mild Steel & Sheet Metal); Steel Joining (Medium Carbon & Low Alloy).

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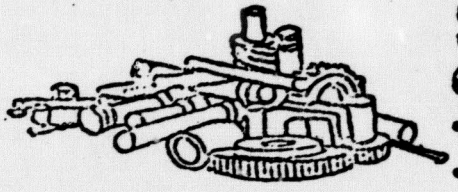
BETTER-THAN-NEW PARTS...AT A FRACTION OF TH

Before RoToTec, how did you handle the problem of worn parts?

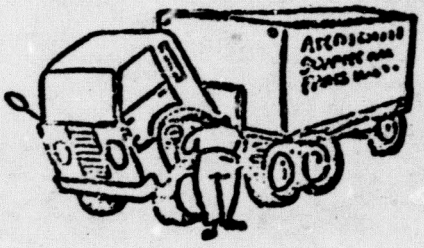


SCRAP the worn part and order a new one?
Okay, except...

- NEW parts are expensive • NEW parts take time for delivery
- NEW parts last only as long as the last new part you bought.

SEND the worn part out for repair?
Okay, except...

- YOU were still at the mercy of high-price repairs and problems of delivery . . .
- YOU could never be sure if the repaired part was even as good as the original.



REPAIR it yourself?
Okay, except...

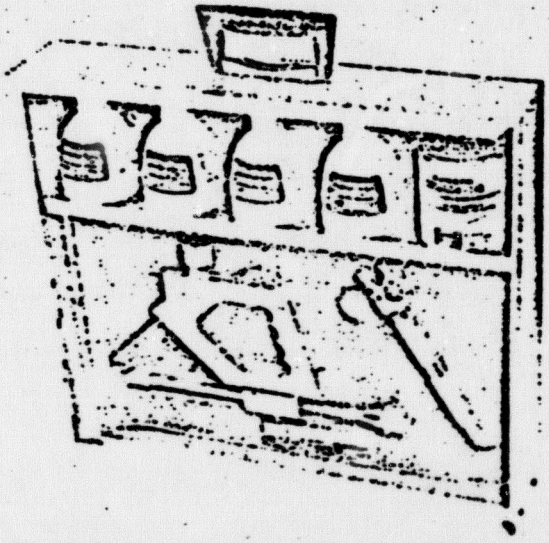
- Conventional repair methods required highly skilled weldors and machinists . . .
- Conventional methods required time-consuming procedures . . .
- In most cases, the repair was questionable and involved high temperatures, warpage, distortion and other stresses . . . plus lots of machining time.

Now, there's a simple, inexpensive, foolproof process to repair shafts, journals and bearing surfaces to *better-than-new* condition. Parts repaired with the RoToTec Process lasts from 2 to 5 times longer than even new parts!

The RoToTec Intro Kit

Repairs so fast . . .
so effectively . . .
so reliably . . .
so safely . . .

You'll have to see it to believe it!



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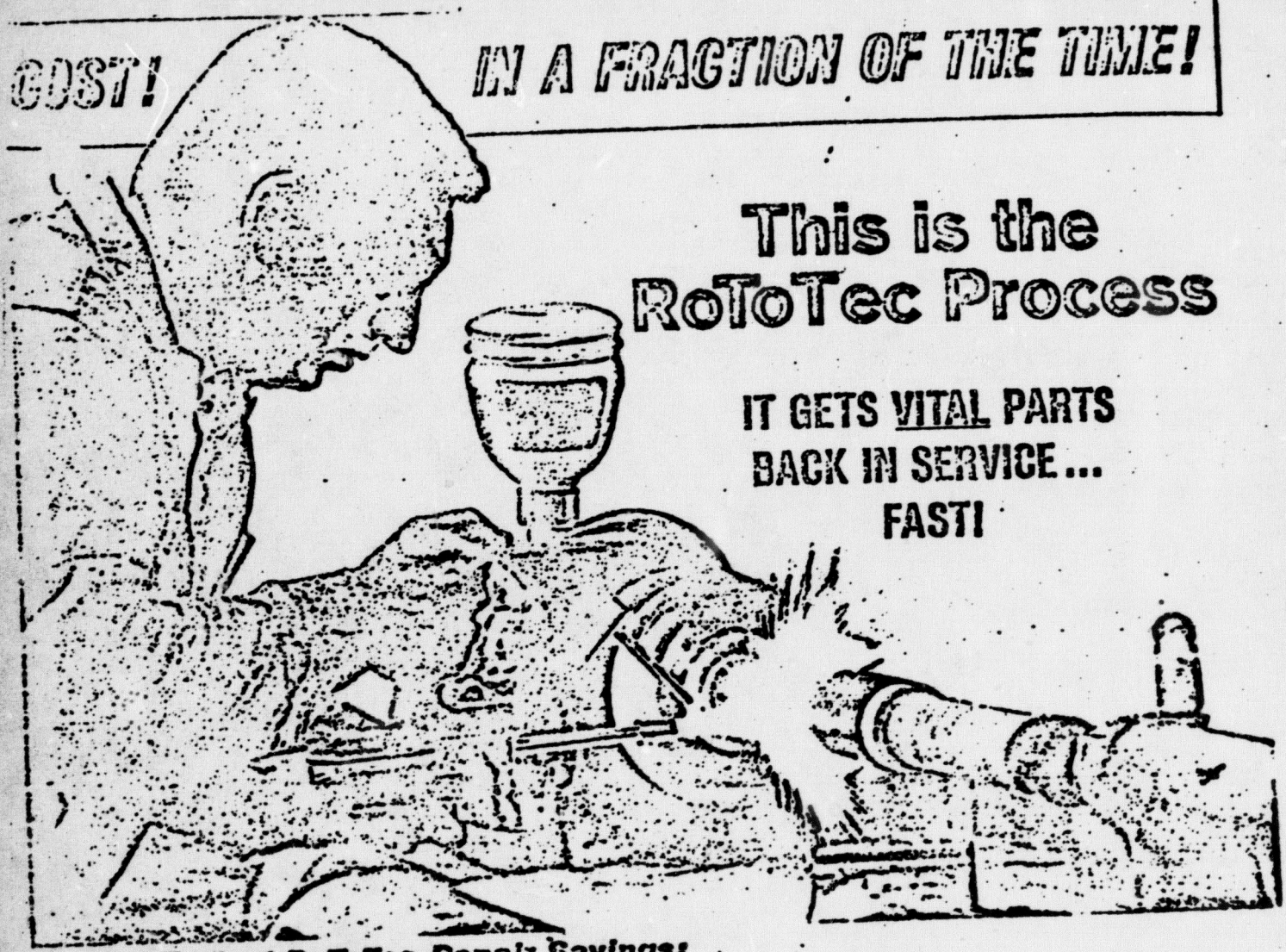
COST! IN A FRACTION OF THE TIME!



This is the RoToTec Process

IT GETS VITAL PARTS BACK IN SERVICE... FAST!

Some Typical RoToTec-Repair Savings:

Part	New Part	RoToTec	Savings
Pump Impeller Shaft	$120.00	$25.00 2" Dia. x 4" lg. Bearing Area	$95.00
Bus Axle (Spindle)	40.00	8.00	32.00
Electric Motor Shaft	60.00	6.50 ea. Bearing Fit	53.50
Automotive Crankshaft	60.00	9.00	51.00
Spline Shaft	140.00	15.00	125.00

If you can run a lathe...RoToTec can "turn" it into a "maintenance control center" for thousands of parts like these...

BEARING AREAS OF ... Armature Shafts • Axles • Bearing Fits • Bearing Race Holds • Fan Shafts • Gland Sections • Guide Rolls • Journals • Mandrels • Packing Glands • Paper Rolls • Propeller Shafts • Pump Packing Sleeves • Rubber Rollers • Shaft Seal Areas • Turbine Shafts

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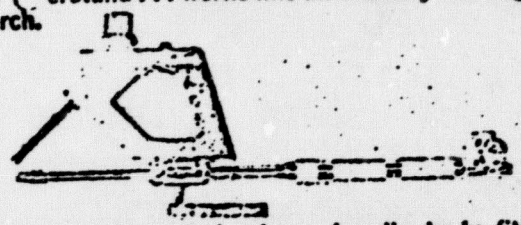
THIS IS THE RoToTec GUN

Built for ruggedness, easy-handling and maintenance-free RoTo-coating. Simple to use, simple to understand . . . works like an ordinary welding torch.



Light, sturdy cast-aluminum handle body fits any operator's grip. Non-stick thumb feed valve controls powder feed. Slide back it's on; slide forward it's off.

Torch body is durable chrome-plated brass. All gas flow is *in-line*. No curves, no spirals.

Powder feed system is *outside* torch. Powder is gravity-fed and injects into flame at precisely the right point for optimum "dwell time". Result: *Perfect* "melts", *perfect* velocity of molten powder particles, *perfect* coatings.

THESE ARE THE RoToTec POWDERS

EXOTEC 29904 The Bond Coat Powder. Exclusive! Self-reacting, exothermic composite powder formulation forms high-strength bond on ferrous metals, cast iron, nickel alloys, stainless steel, and bronze. Provides the ideal intermediate surface for all subsequent RoToTec final coats.

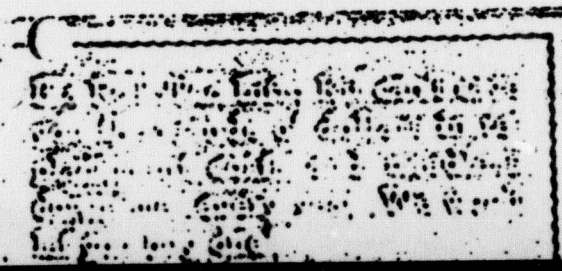
RoToTec 19985 Unique chemistry designed to produce machinable final coatings. Coatings exhibit high internal strength and extraordinary metal-to-metal wear resistance.

RoToTec 19910 A powder designed to produce extremely hard, long wearing, grindable coatings. Especially recommended for bearing areas subjected to severe metal-to-metal frictional wear and parts whose substrates are hardened steel.

RoToTec 19850 An extremely pure, oxide-free bronze powder. Designed for applications where typical friction-free, wear-resistant qualities of bronze bushings and bronze bearing surfaces are required. Microporous structure of coating exhibits outstanding oil-retention features which promote longer service life. Coatings are easily machined with standard carbide cutting tools . . . and produce smooth, bright finished surfaces.

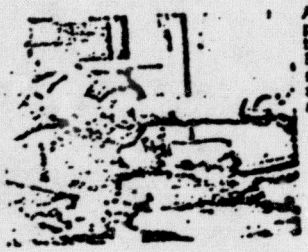
- designed to work together.
- designed to make repaired parts last from 2 to 5 times longer than *even new parts.*

Deposit efficiencies of all RoToTec Powders: Over 90%.



F YOU CAN RUN
\ I ATHE, YOU
CAN LEARN TO
ROTO-COAT IN
A HALF HOUR.
T'S THAT EASY!

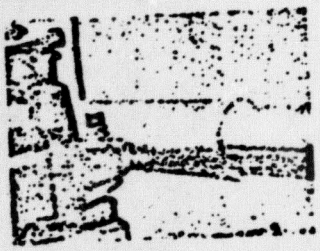
Simple Preparation!



After cleaning and degreasing part, mount it in a lathe so that it runs true. Brush on Eutectic Solution #103 to protect all adjacent areas where powder spray is not wanted.

Quick Machining!

Undercut worn area. Thread undercut section. Rotate part at recommended speed and run a torch flame over threaded portion to evaporate all surface moisture. You're ready to spray!

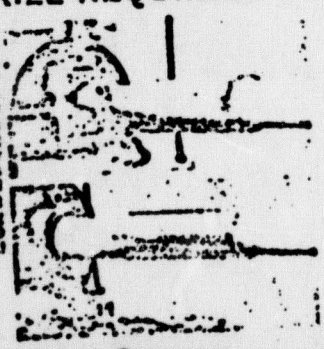


Lightweight RoToTec Gun For Hand-Held Or Tool Post-Mounted Applications!

Start RoTo-Coating with EXOTEC 2S904 (bond coat) . . . until entire worn surface is covered with a thin layer of material. One pass usually does it!

NO SPECIAL WELDING OR SPRAYING SKILL REQUIRED!

Spray final coat. Use appropriate powder for the job. RoToTec 19955 for machinable buildup; RoToTec 19310 for super-hard, grindable buildup; RoToTec 19850 for bronze surfaces. Part doesn't heat up . . . so there's no waiting to get an accurate caliper or micrometer reading. Repairs are to tolerance. Final grinding to size takes just minutes. Remove masking and PART IS READY TO GO BACK IN SERVICE!



Works Off Standard Oxygen And Acetylene Fuel Supply!

E 88

WHY A RoToTec INTRO KIT IS THE SINGLE, MOST IMPORTANT TOOL YOU BUY THIS YEAR!

The Revolution in "Metallizing"

Every so often, old ideas and concepts wear out . . . just like parts!

Take the word "metallizing". It used to be thought of as a complex, tricky process requiring expensive hardware, a lot of adjustments and re-adjustments of flowmeters, valves, wire feeds, etc., plus a vast amount of technical skill. Any slight variation, any deviation could eventually turn up as a coating failure.

Until the RoToTec Process came along . . .

Today . . . with a simple, easy-to-use RoToTec Kit any shop, any machinist, any maintenance worker who can run a lathe can get the most professional, long-lasting repairs on worn shafts, journals and bearings—repairs that used to require equipment costing many times as much plus the special skills of a highly trained "metallizer".

What's behind the success of RoToTec?

TWO THINGS: 1) The ingenious simplicity of the RoToTec Gun, and . . .

2) The unique reliability of the EXOTEC bond coat powder.

Together, they can send your productivity and your profits soaring! The Eutectic Application Specialist that sells you your kit will stay with your operator and have him RoTo-Coating in a *half hour!*

The RoToTec Process is the ultimate in simplicity. It's the ultimate in dependability too . . . because there's no opportunity for mistakes. It's also the ultimate in economy . . . because the kit is so inexpensive.

Once you see the RoToTec Process, you will agree . . . no other method of repair comes close.

There is only one company that could do it! EUTECTIC.

The Eutectic Corporation is unique in its total approach to the field of maintenance and repair techniques and technology. Our record of successful development in virtually every phase of equipment, processes and materials for the most practical and effective repair of metal parts is unmatched by anyone. For over 60 years, we have led the world in welding, brazing, soldering and powder spraying achievements. Although the RoToTec Process — the equipment and the powders—represents an exciting breakthrough in "cold process" metal surfacing . . . it is a logical and natural extension of the company whose advancements in research, development and engineering preceded it.

To broaden your maintenance welding technology . . .

The Eutectic-Castolin Institute Provides Application Courses In Your Plant.

Here are the Courses most in demand by the leading industrial corporations.

The EUTECTIC-CASTOLIN INSTITUTE FOR THE ADVANCEMENT OF MAINTENANCE AND REPAIR WELDING TECHNIQUES has prepared a comprehensive selection of welding courses to answer the specific needs of industry. Other courses are available on request. For information, contact your local Application Specialist, or write directly to the EUTECTIC-CASTOLIN INSTITUTE FOR THE ADVANCEMENT OF MAINTENANCE AND REPAIR WELDING TECHNIQUES.

MAJOR INDUSTRIES

Construction and Earth Moving; Mining; Foundries; Railroads; Pulp & Paper; Steel Mills; Chemicals; Cement; Automotive; General Maintenance and Machine Shop; Petroleum; Sugar Mills.

MAJOR APPLICATIONS

Forming and Stamping Dies; Machine Overlays; Pattern Repairs; TIG—General; Silver Joining; Forging Dies; Gears.

OVERLAY APPLICATIONS

Buckets; Agriculture Implements; Crushers; Conveyors, Screws; Mixers, Scrapers; Valves; Hard Surfacing—General; Hard Surfacing—Severe Abrasion and Wear.

ADDITIONAL LITERATURE

Aluminum Repair; Bronze Repair; Cast Iron Repair; Copper Base Alloys Joining; Stainless Steel; Steel Joining (High Carbon & High Alloy); Steel Joining (Mild Steel & Sheet Metal); Steel Joining (Medium Carbon & Low Alloy).

EUTECTIC-CASTOLIN INSTITUTE FOR
THE ADVANCEMENT OF MAINTENANCE
AND REPAIR WELDING TECHNIQUES
40-40 172nd Street, Flushing, New York 11358

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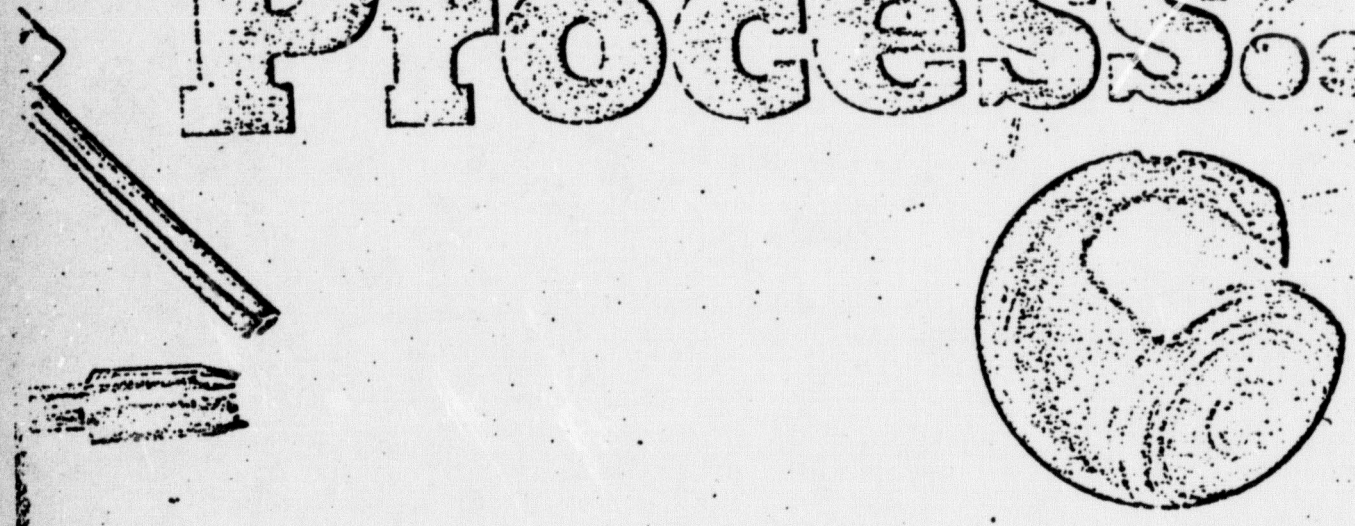
E 89

This is the Rototeg Process...



DX
FM

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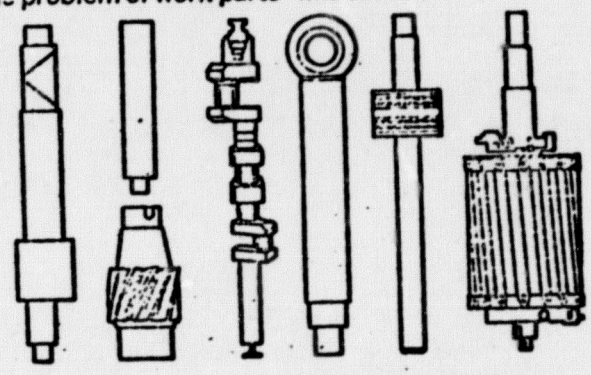
RoToTec gives you professional, long-lasting repairs on worn bearing areas of shafts • rolls • journals • armatures • sleeves • end bells • packing glands • seal areas • and more...

RoToTec ... one of our SUPERLIFE line of outstanding products and processes designed to *significantly extend* the *service life* of every part that wears!

Before RoToTec ... how did you handle the problem of worn parts like these...?

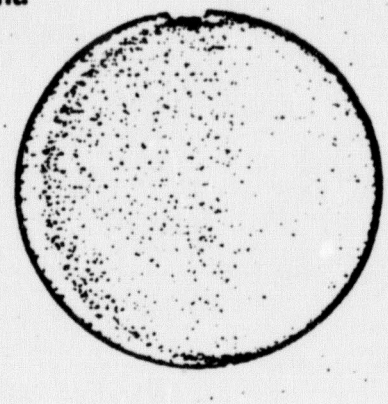


**Scrap the worn part and order a new one?*

Okay, except... new parts are expensive and getting more expensive everyday.

New parts are subject to unacceptable delays in manufacture, delivery, etc. . . . causing extensive downtime.

New parts last only as long as the last new part you bought.



Large inventories of replacement parts can drain up to 30% of your profits, tie up valuable capital, floor space and labor.

**Send the part out for repair?*

Okay, except... you're still subject to the problems of high prices for repairs and long waits for delivery of the repaired part.

You can never be sure that the repair is reliable or that the part will hold up as well as the original in service.

**Repair it yourself?*

Okay, except... conventional repair methods require highly skilled personnel *and* complicated and expensive equipment.

Conventional repair methods require time-consuming sleeving, plating, welding and/or machining operations.

Conventional repairs are often questionable as to effectiveness and reliability . . . most involve high temperatures leading to possible warpage, distortion and other stresses in the original part.

Now, there's a simple, inexpensive, fully reliable method for bringing worn bearing areas on cylindrical parts back to dimension!

It gets parts vital to your production back to service fast...and the repaired part will most likely outlast any other repair process, new part replacement and/or the original!

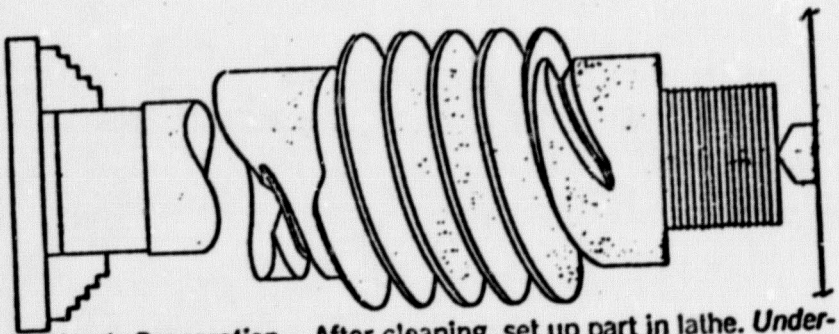
All RoToTec coatings provide frictional wear resistance far superior to that of the original surface!

You can learn to RoTo-coat in a half hour. It's that easy!

50372

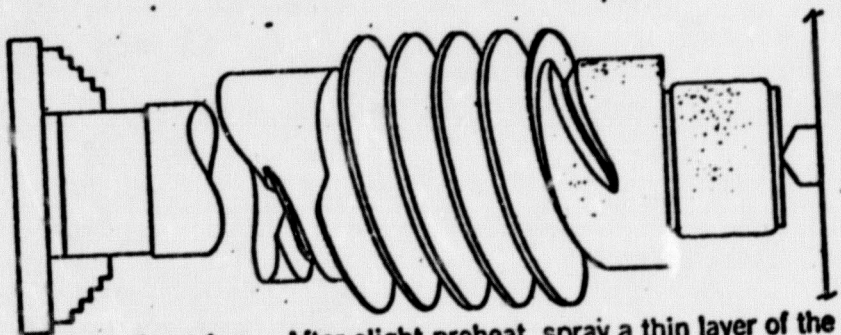
...Corporation 1972 • ® Reg. T.M. • 4157 • Printed in U.S.A.

1.



Simple Preparation...After cleaning, set up part in lathe. *Undercut* the worn bearing area. Then *thread* the undercut section. Masking solution protects adjacent areas from overspray.

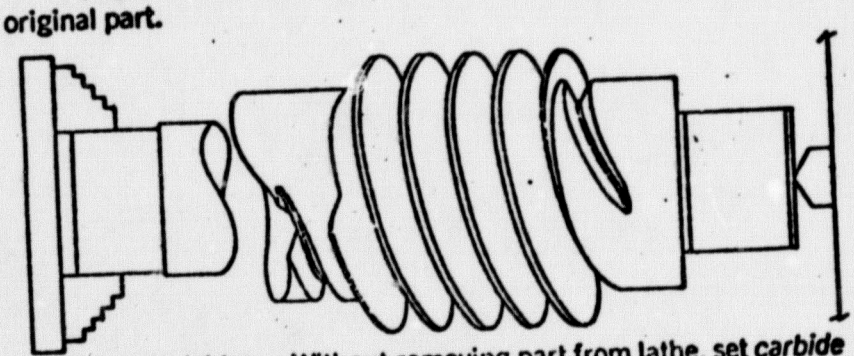
2.



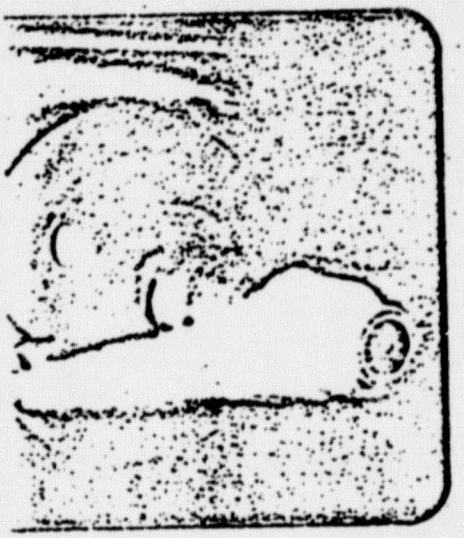
Simple Spraying...After slight preheat, spray a thin layer of the BOND COAT-ExoTec 29904 powder. This is the key to the extraordinary reliability of the RoToTec Process...producing high-strength, metallurgically-bonded coatings in the *AS-SPRAYED* condition. Immediately spray the final coat powder until the buildup is slightly oversize.

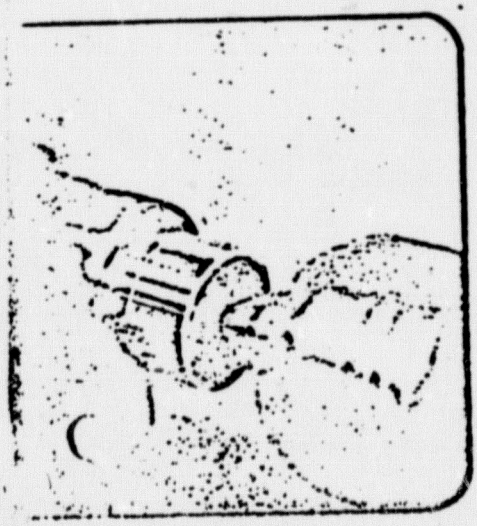
No extra "fusion" step is required. Only negligible heat is transmitted to the part, no part need ever reach temperatures over 500°F. That's why RoToTec is called the "COLD" Process. Never any danger of warpage, distortion or adverse metallurgical side-effects in the original part.

3.



Simple Finishing...Without removing part from lathe, set *carbide cutting tool* for standard machining. After one or two cleanup cuts and a finishing cut, the bearing area has a smooth, gleaming "new surface" ready to go back in service.





This is the RoToTec Gun

Designed for Immediate Use...

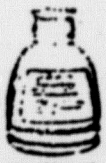
- No compressed air!... just standard oxyacetylene fuels!
- No flow meters! • No special welding skills!

Designed for Fast, Precise Repairs...

- No setup time! • Quick powder module changes! • Light and portable!

Designed for Long, Trouble-Free Use...

- Rugged construction...no maintenance! • No noise! • No odor,... no smoking or fuming! • No moving parts—powders are gravity fed!



ExoTec 29904

The Bond Coat Powder. Exclusive! Self-reacting exothermic powder forms the perfect base coat prior to all final coat spraying. ExoTec 29904 is the key to RoToTec's superiority. It produces the strongest, as-sprayed metallurgical bond to *every base metal* (except pure copper). It is the key to RoToTec's extraordinary reliability and effectiveness as a life-prolonging process.

DuroTec 19910

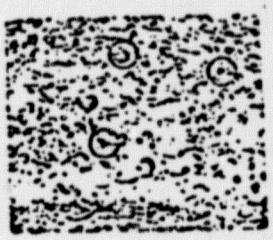
Final Coat Powder. A powder designed to produce a coating of higher hardness, requiring grinding for finishing operations. Especially recommended for bearing areas subjected to severe friction accompanied by *mild abrasion*.

LubroTec 19985

Final Coat Powder. Unique chemistry designed to produce tough, wear-resistant coatings for the use on a majority of parts. Coatings exhibit high internal strength and exceptional frictional wear resistance. Coatings are fully machinable with standard carbide cutting tools.

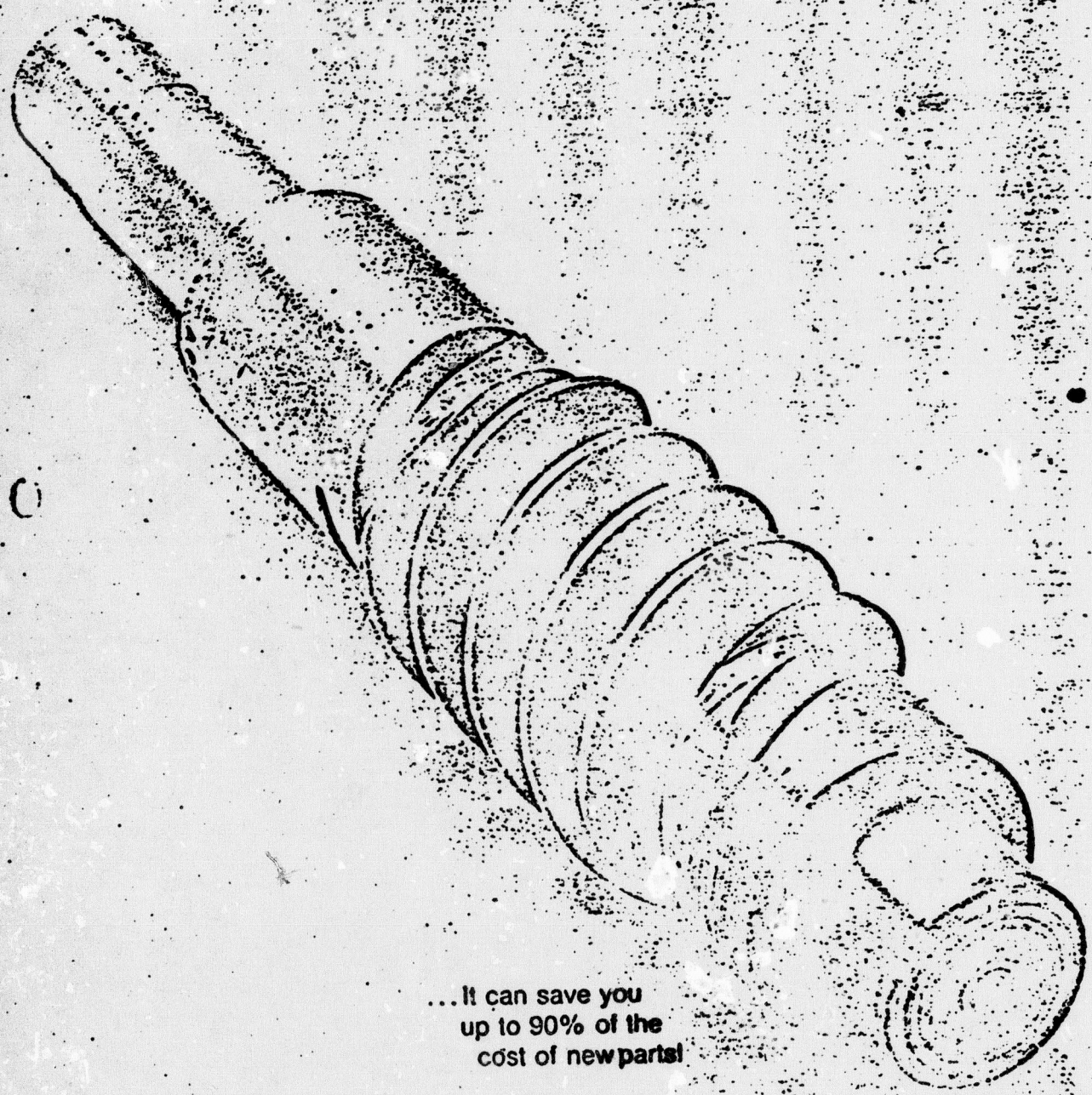
FrixTec 19850

Final Coat Powder. An extremely pure, bronze type powder. Designed for applications where bronze bushings and bronze bearing surfaces are desired. Coatings work-harden in service. FrixTec 19850 is easily machined with standard carbide cutting tools and yields a smooth, bright finish.



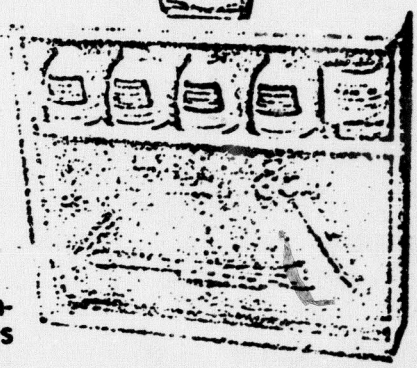
All RoToTec Powders produce coatings exhibiting the highly desirable characteristics of CONTROLLED PERMEABILITY. On the left is an actual photomicrograph (50 X magnification) of a typical, as-sprayed coating. From top to bottom, the photo shows a layer of LubroTec 19985, a layer of ExoTec 29904 and finally the mild steel substrate.

The circled areas in the final coat are the largest of a network of microcavities, which accounts for approximately 6% of the total volume. These cavities serve as an internal reservoir for absorbing, retaining and releasing lubricant. This, in turn, permits a thin film of oil to protect the mating bearing surfaces in service...providing an additional factor for reducing frictional wear.



...It can save you up to 90% of the cost of new parts!

The Revolution In Metal Spraying!



THIS KIT...
Can Be The Single, Most Important Tool You Buy This Year!

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Today...with a simple, easy-to-use RoToTec Kit, just about any shop, any machinist, any maintenance worker can get the most professional, long-lasting repairs on worn shafts, journals and bearings—repairs that used to require equipment costing many times as much plus the special skills of a highly trained "Metal Spray Technician".

What's behind the success of RoToTec?
Two Things:

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2) The unique reliability of the EXOTEC bond coat powder.

Together, they can send your productivity and your profits soaring!

The RoToTec Process is the ultimate in simplicity. It's the ultimate in dependability too...because there's no opportunity for mistakes. It's also the ultimate in economy...because the kit is so inexpensive. The repair capability of one kit can easily save you three, four and five times the initial investment. By the time you're ready to order additional powder, your savings will be even greater.

Once you see RoToTec Process, you will agree...no other method of repair comes close.

There is only one organization that could do it...EUTECTIC-CASTOLIN!

The EUTECTIC-CASTOLIN INSTITUTE FOR THE ADVANCEMENT OF MAINTENANCE AND REPAIR WELDING TECHNIQUES is unique in its total approach to the field of welding technology. Our record of successful development in virtually every phase of equipment, processes and materials for the most practical and effective repair of metal parts is unmatched by anyone.

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Construction and Earth Moving; Mining; Foundries; Railroads; Pulp & Paper; Steel Mills; Chemicals; Cement; Automotive; General Maintenance and Machine Shop; Petroleum; Sugar Mills.

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EUTECTIC-CASTOLIN INSTITUTE
FOR THE ADVANCEMENT OF MAINTENANCE AND REPAIR WELDING TECHNIQUES
40-40 172nd Street, Flushing, New York 11358
Sponsored by the Eutectic Corporation

53676

TESTED AND RECOMMENDED

RoToTec Powders

DX
FR

RoToTec 19910 FINAL COAT

SUPER HARD

CHARACTERISTICS OF POWDER AND COATING

RoToTec 19910 is a specially-formulated powder which is designed to produce unusually hard coatings for those applications which require extra Hardness to resist particularly severe service conditions.

FOR USE ON THE FOLLOWING BASE METALS
Ferrous metals • Cast Iron • Stainless steels • Nickel alloys

DEPOSIT EFFICIENCY Over 90%

MACHINABILITY Not machinable—finish by grinding.

PACKAGING 1200 grams per Spraypak Module
4 Spraypak Modules per Carton

RoToTec 19850 FINAL COAT

SUPERIOR BRONZE COATING

CHARACTERISTICS OF POWDER AND COATING

RoToTec 19850 is special, aluminum-bronze powder designed to yield exceptionally clean, smooth coatings. It is recommended where non-ferrous, low coefficient of friction bearing surfaces are desired. Deposits work harden in service.

FOR USE ON THE FOLLOWING BASE METALS
Ferrous metals • Nickel alloys • Stainless steels • Bronzes • Cast iron

DEPOSIT EFFICIENCY Over 90%

MACHINABILITY Machining with standard carbide tools yields exceptionally smoth, bright, finished surfaces.

PACKAGING 1200 grams per Spraypak Module
4 Spraypak Modules per Carton

E 95

EUTECTIC CASTOLIN INSTITUTE FOR THE ADVANCEMENT OF MAINTENANCE AND REPAIR WELDING TECHNIQUES

Advanced School for the Study of Applications of Maintenance Welding

[illegible]

RoToTec Powders

For 1-STEP Cold Process Metallized Coatings
Designed Exclusively For Use With The RoToTec Gun

EXOTEC 29904 BOND COAT

RELIABLE BONDING

CHARACTERISTICS OF POWDER AND COATING

EXOTEC 29904 is a unique, self-reacting, composite powder. Its special formulation promotes a powerful exothermic (heat-releasing) reaction during deposition. The impact of the superheated powder particles on the prepared substrate (base metal) achieves metallurgical-type bonding. Interlocked structure of the solidified particles provides the optimum surface for all subsequent final coats.

FOR USE ON THE FOLLOWING BASE METALS
Ferrous Metals • Cast Iron • Nickel Alloys • Stainless Steels

DEPOSIT EFFICIENCY Over 90%

RECOMMENDED COATING THICKNESS Between 0.004" and 0.008"

PACKAGING 1000 grams per Spraypak Module
4 Spraypak Modules per Carton

SPRAY PARAMETERS See RoToTec Hand Book

RoToTec 19985 FINAL COAT

MACHINABLE WEAR RESISTANT

CHARACTERISTICS OF POWDER AND COATING

RoToTec 19985 is a general-purpose high-alloy powder designed to produce successful coating repairs on an extremely wide range of shafts, journals and bearing surfaces. It is the most versatile and generally-recommended powder, and provides coatings with outstanding frictional wear resistance . . . capable of performing better and lasting longer than most new or original parts.

FOR USE ON THE FOLLOWING BASE METALS
Ferrous metals • Cast Iron • Stainless steels • Nickel alloys

DEPOSIT EFFICIENCY Over 90%

MACHINABILITY Excellent with standard carbide cutting tools.

PACKAGING 1200 grams per Spraypak Module
4 Spraypak Modules per Carton

OUTSTANDING FEATURES OF ALL ROTOTEC COATINGS

96 3

50837

Moguloy

Moguloy M-55

Nickel-Aluminum
SELF-BONDING POWDER

MIX POWDER BY TUMBLING CAN END OVER END.

KEEP TIGHTLY CLOSED AND RETURN POWDER TO THIS CONTAINER WHEN NOT SPRAYING.

M-55

Nickel-Aluminum
SELF-BONDING POWDER

_____pounds net

NOTE:
THERE MAY BE AIR SPACE LEFT IN THIS CONTAINER BUT IT DOES, HOWEVER, CONTAIN THE NET WEIGHT AS STATED ON THE LABEL.

Moguloy M-55 provides a self-bonding base coating that automatically has a suitable surface for bonding other sprayed materials. Undercoats of only 4 to 6 mils are sufficient. No after heating is required. May be used for high temperature applications. May be used by itself for uses subject to heavy wear.

Metallizing Company
OF AMERICA, INC.

C0014

Metallizing Company of America, Inc.
3520 W. Carroll Avenue, Chicago, Illinois 60624 U.S.A.
NEW YORK • SULLIVAN, ILL. • LOS ANGELES
Made in U.S.A. Printed in U.S.A.

Moguloy

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one pound net

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OF AMERICA, INC.

C0013

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Made in U.S.A. Printed in U.S.A.

DX
GA-

97

Deleted-87

( ) [illegible] complete listing of all [illegible] for metallizing alone with [illegible] and quantities. Describe powder applications for each type alone.

( ) [illegible] Electronic equipment: Electronic and [illegible] required [illegible] and [illegible] controls, wire coating units, [illegible], etc.

( ) [illegible] with standard automatic [illegible] the TJ-2 [illegible] [illegible] Many metallizers can [illegible]. High capacity models [illegible].

( ) [illegible] Automatic Unit: For a positive wire feed control through a [illegible], constant speed electric motor. High [illegible] rates for long [illegible].

( ) [illegible] Complete system for [illegible] coating for remote [illegible] and automatic [illegible] operation.

( ) [illegible] STATIONARY Unit: Consists [illegible] of new, advanced T-7 gun for [illegible] feed [illegible], controls and [illegible]. [illegible] for extreme mobility. Can be used for [illegible] coating [illegible].

( ) [illegible] Twice the [illegible] of [illegible] molybdenum. Will spray three times [illegible] 4 to 5 times faster than current models for [illegible], longer [illegible] operation.

( ) [illegible] Wire Feeds: Provides [illegible] control, automatic operation of a complete [illegible] system. Details and illustration models for [illegible], [illegible] to [illegible].

( ) [illegible] Wire Flame Spraying on [illegible] surfaces or [illegible] coating [illegible] corrosion is a must. Describe [illegible] and [illegible] equipment and [illegible].

( ) SELF-BONDING METALLIZING POWDER: Metaloy N-55 is a new nickel-aluminum powder that can be applied to most metals without initial preparation. Used as an undercoating for other metals it exhibits excellent bonding power. May be used alone for areas subject to high wear.

( ) [illegible] Equipment: It is very [illegible] high pressure [illegible] spray system for [illegible], plastics [illegible] ceramic parts. Can be used with [illegible] water, with or without [illegible].

( ) Parts [illegible]: It is in [illegible] for [illegible] pressure ceramics or plastics can be supplied. [illegible] Metal coatings [illegible] vacuum and pressure for batch [illegible] equipment.

[illegible] [illegible] [illegible] [

METCO INC.
OF AMERICA, INC.
3520 W. Carroll Ave. • Chicago, Illinois 60624
Phone (312) 722-3710

new product information

[illegible]

Self-Bonding Nickel-Aluminum Metallizing Powder

Substantially Reduces Metallizing Preparation Costs!

Meculoy M-55, when sprayed on most metals, produces a metallurgical, exothermic reaction that fuses to the base material. This provides a self-bonding base coating that automatically has a suitable surface for bonding other sprayed materials. Surface preparation, such as grit blasting or rough turning, can often be eliminated. Equipment costs are reduced as well as the time involved. Meculoy M-55 can be applied as a basic step in the metallizing operation with a quick, simple switch to the finish powder. If necessary, a wire metallizing gun may be used for finishing materials.

The typical bond strength of Meculoy M-55 is in excess of [illegible] psi. It is not only excellent as a self-bonding undercoating but may also be used as an abrasion resistant coating by itself for areas of high wear. It can be machined with carbide tools.

Meculoy M-55 resists oxidation and thermal shock. It is an excellent undercoating for ceramics due to its high nickel content and exhibits nickel's high heat resisting properties. Meculoy M-55 is uniformly manufactured to eliminate material separation and its mesh size is properly filtered for smooth feeding.

SPECIAL INTRODUCTORY OFFER!

So that you may try Meculoy M-55, we will allow you a 20% discount on a trial, one-pound size...$12.00 for the first pound! Regular prices, per pound, are: 1#-$15.00, 5#-12.75, 10#-11.75, 25#-11.35, 50#-10.90, 100#-10.45, 250#-10.00, 500#-9.75.

Also

NEW! Universal model U-7 Powder/Wire gun sprays metals, ceramics, exothermics and cermets! This is the perfect metallizing gun for Meculoy M-55 powder. It switches easily and quickly from metal coating to a job calling for other types of coatings...all with only one gun. May be used without compressed air for metal spraying. The perfect gun for all size shops! Send for literature.

Dept. Tech. 85 4'

10/1/m

60009

DX
GC

E 100

OPTIMUM CLUB
40-40 172nd Street, Flushing, New York 11358

COMPARATIVE POWDER WELDING TECHNOLOGY

PROCESS COURSE #4

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GE

CONFIDENTIAL

DIRECTIONS FOR USING THE COMPARATIVE POWDER PROCESS COURSE

1. Course material may be shown in advance to concerned executives as a convincing aid in enlisting their support. The sincerity of your offer of potential savings through permanent aid and training, backed up by evidence in our book, "How to Save Millions", and in other New Era sales tools will aid Golden Opportunities for executive backing in all your presentations.

2. Role-Practice both the verbal and welding skills portions your presentation. Your field Sales Supervisor and the Flushing Training Department will be pleased to assist in every way possible.

3. Select your audience to include one or more of the following:

   a. Customer executive personnel empowered to effect purchase decisions. OR
   b. Customer personnel who are to receive process training as a result of prior purchase or permanent technical assistance commitment. OR
   c. Professional, Educational, Managerial, or Skilled Craftsmen groups whose individual business needs may presently or in future be benefitted by knowledge of Eutectic's maintenance designed powder processes. OR
   d. Internal manpower development needs of the Eutectic-Castolin Institute, e.g., advanced training classes.

4. The brief discourse on historical metallizing process development from conventional wire spray, through compressed air backed powder guns is designed to be used <u>only</u> when leading into comparative discussion of Eutectic's unique <u>maintenance designed powder processes.</u>

5. Prepare your presentation in advance to insure a smooth flowing course, including appropriate powder processes <u>plus</u> at least one each of the following:

   a. A EutecRod selection relevant to customer application needs such as #BronzoChrom #185FC for gear teeth.

   b. A EutecTrode selection relevant to customer application needs such as Xuper ExoTrode and Xuper NodulTec 2240 Cast iron for pump housing repair

CONFIDENTIA

c. A pump housing arc alloy demonstration can be effectively preceeded by a Eutalloy presentation on the impellor blades of the same pump.

d. The impellor repair procedure can effectively be preceeded by a shaft journal repair presentation with RoToTec.

6. Audio-visual aids, chalk talks, application parts to be weld imporved, and demonstration supplies should be set up in advance. AAP's selected to support your presentation, along with a Survey Form, some blank AAP's, literature and your order pad should also be prepared in advance.

7. Study all applicable Institute literature on product, process, applications, and base metals. Be sure to check your technique against the standards given in the Golden Course Theory Manual, Golden Course Booklets and Industry Guides.

8. If static (black board or classroom) lecturing preceeds live parts repair demonstration, keep the time under thirty minutes. Ask and/or induce questions that generate application discussion by customers. Each application need that customers admit to can easily become 1/4th of your Golden Order. This opportunity may also permit inquiry into cost, frequency and present practices to acquire survey and AAP information needed for future management support.

9. Remember that this short course, whether given in-plant or at STDC, is only one link of a continuous chain, our Permanent Aid & Training Program. Be sure your customer appreciates this also. It should be worth many dollars to all concerned.

INDEX

SECTION

1 Conventional Powder Process Descriptions
Comparative Values in Production and/or Maintenance Applications

2 The RoToTec Process
Designed for Maintenance

3 The Eutalloy Process
Designed for Maintenance

4 Powder Manufacturing and Packaging

5 Blackboard Notes

6 Basic Shaft Knowledge for Weldors

7 Basic Gear Knowledge

8 Basic Pumps, Impellors and Rotor Assemblies

9 Basic Valve Construction and Rebuilding

DRAFT

PROCESS COURSE #3

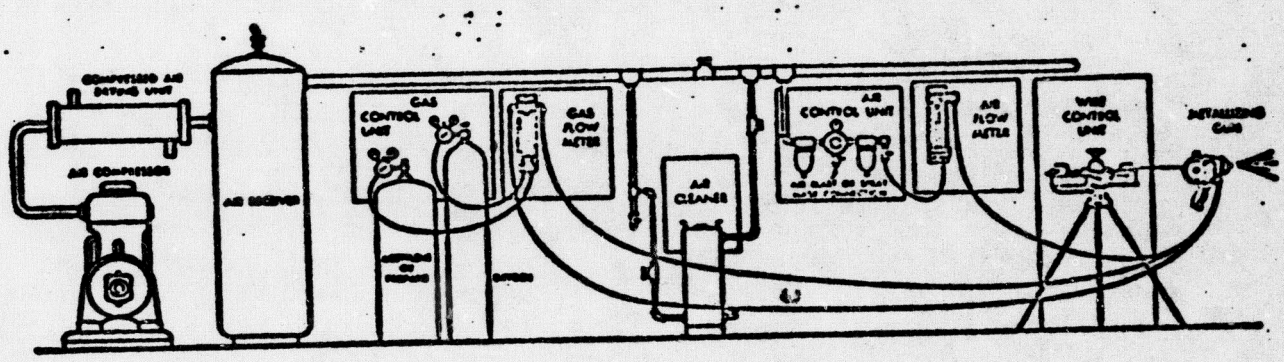
Practical Metal Spraying with Oxy-acetylene in Maintenance

The basic techniques are not new gentlemen, just familiar. They are usually learned on-the-job instead of in welding school or during apprenticeships. Since the machine shop is as frequent an arena as the weld shop, the simple techniques have remained a mystery to some users who could benefit by them. A basic knowledge of the filler metals available and the range of application tools is as essential to successful usage as is knowing where and when to use them. Today, we hope to clarify all these areas for you and explain the principles involved. All of the process variations have just one thing in common - they are designed for overlaying or buildup and not for joining.

Oxy-Acetylene is used as the heat source to melt and/or soften the filler metal. In the more complicated production tools, compressed air is also used to propel the molten or softened filler metal onto the base metal. The simpler maintenance designed processes use fuel gas pressures as the propellant to move filler metal to the work in progress. Application temperatures may vary from 200° F. at base metal surface, to as high as 1800° F. Obviously, the "colder" processes are of value when changes to existant base metal properties must be avoided. The "hot" processes will have all the qualities of "bronze" weld or brazed surfaces and exhibit

greater bond strength. "Cold" process deposits are usually porous in nature, and this may be an advantage when lubricants are allowed to penetrate, as in shaft journals. "Hot" process deposits are usually dense and homogoneous. This prevents any absorption of corrosive agents.

We might now proceed to classify all available methods and describe them in practical terms of maintenance need.



WIRE METALLIZING

Compressed air is fed to a gun for the following purposes:

a. Drive an air turbine motor that pulls filler metal in wire form from a reel.
b. The oxy-acetylene flame then melts the tip of the wire and the compressed air then blows the molten drop of filler metal on the work piece.

ADVANTAGES

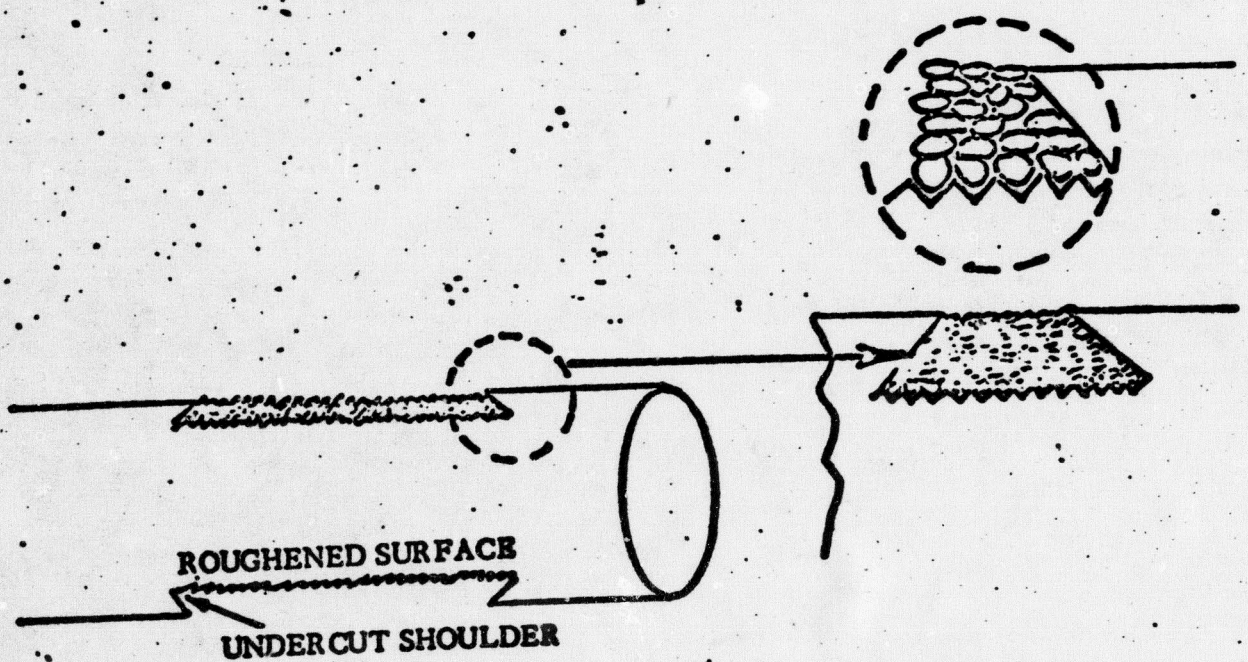
a. Low base metal temperature
b. Controlled high production rate
c. Reasonably priced application to shafting repairs.
d. Can be used for corrosion protection of flat surfaces

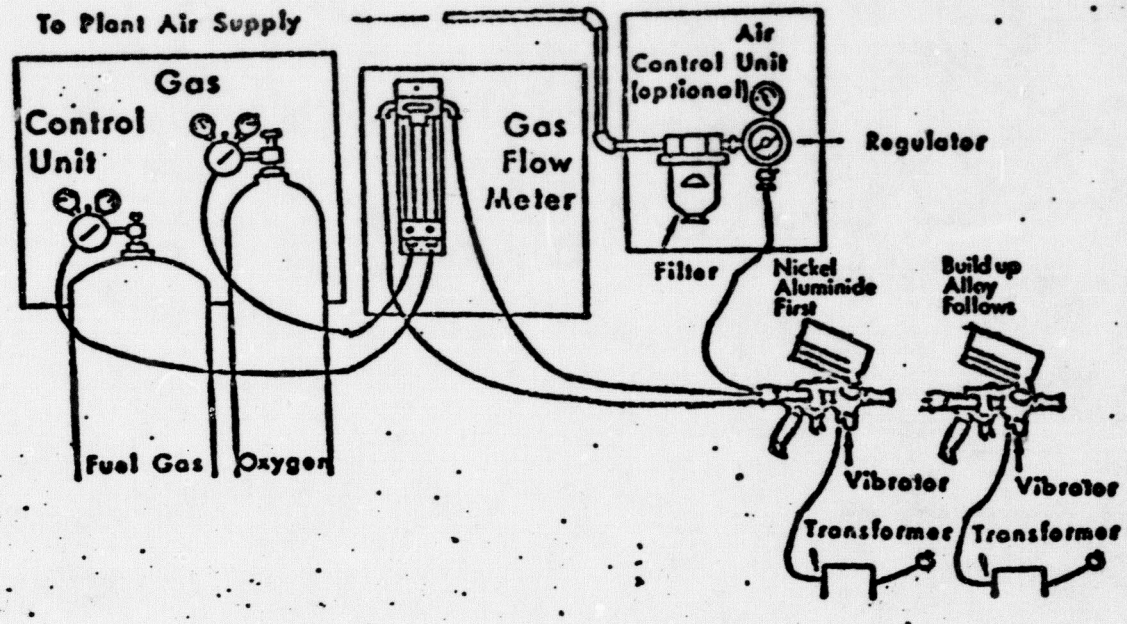
DISADVANTAGES

a. Air turbine noise
b. Odor from burned off wire components
c. Large number of complex components requiring maintenance
d. High first cost for equipment
e. High operator skill requirements
f. Extensive surface preparation required.
g. Generally low peel strength of deposit.
h. Excessive nozzle wear
i. High set up time for small jobs

In the course of development pure molybdenum wires were developed for base coat usage to enhance bond strength. While stronger, the thin molybdenum coat is comparably brittle. Recently, nickel aluminide wires have become available for an even better bond coat, but, as the diagram would indicate, the degree of difficulty in changing wires on the same job has not made the 2 wire process popular in maintenance.

Without a bond coat this type deposit may be described as a porous sleeve that has been shrink fitted to a roughened undercut surface. At best, each sprayed droplet is locked to each other by point contact and the mass is held in place by surface roughness and the shouldered ends of the undercut.





POWDER METALLIZING (2 Step Cold Process)

ADVANTAGES

Using similar, and still complex equipment, a thin base coat of nickel aluminide powder is laid down first. Theoretically, the powder ignites when it hits the flame, generating extra heat within each particle on the way to the work, and actually welds itself to the critically prepared surface. The bond coat surface then will be better at gripping the buildup layers than a mechanically roughened base metal would have been. The buildup powders available include a wide variety of chromium nickel and bronze alloys.

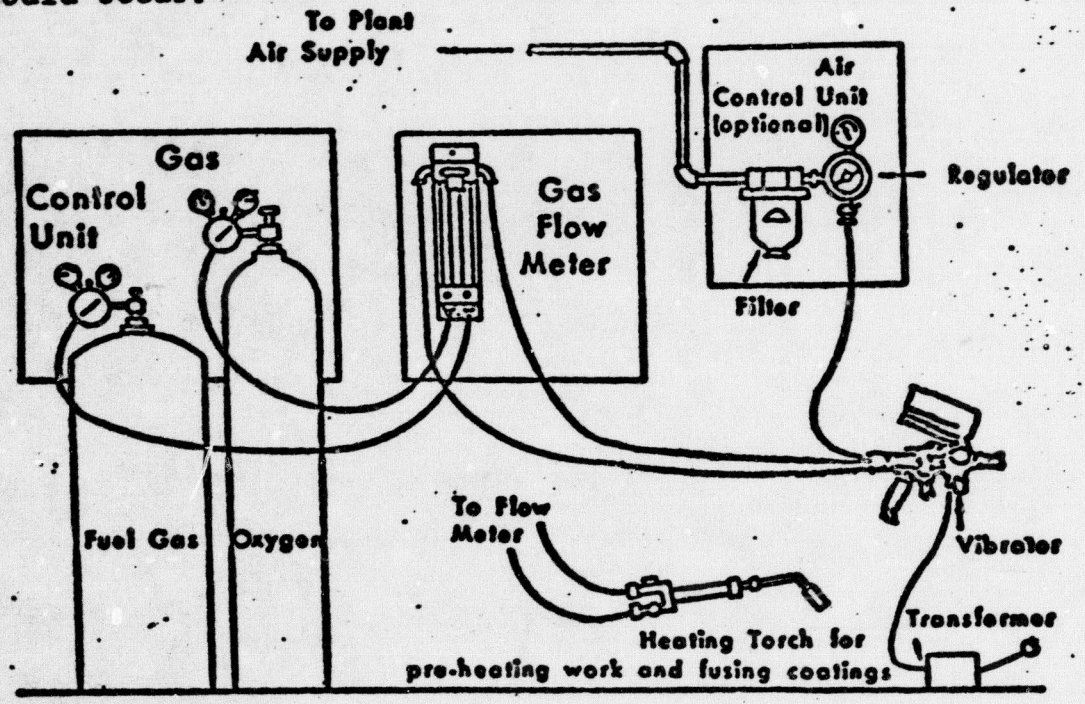
DISADVANTAGES

a. Large number of complex components requiring maintenance
b. High first cost for equipment
c. High operator skill requirements

POWDER METALLIZING - SPRAY AND FUSE (2 Step Hot Process)

ADVANTAGES

The same equipment can be used, but with chemically different powders that contain boron and/or silicon additions. This additional alloying will permit a "brazing" effect to take place when the deposit is reheated to brazing temperatures without any separate fluxing needed. A dense fused weld should occur.



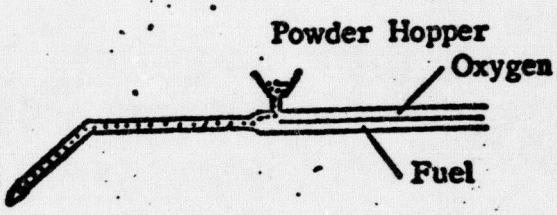
DISADVANTAGES

a. Large number of complex components requiring maintenance
b. High first cost for equipment
c. High operator skill requirements
d. Low tolerance for errors
e. Fusing temperatures required double the time to complete jobs, and frequently causes unwanted changes to the base metal

The above processes are all good in any shop where usage is continuous and operator skill can thus develop. They are both basically "tied down" to a lathe for use on cylindrical surfaces. Since capital investment is high, and high operator skills are needed, the maintenance user frequently must accept expensive outside services.

PORTABLE CONVENTIONAL (1 Step Simultaneous Spray & Fuse Torches)

These simple devices do not need compressed air to move their self-fluxing powders to the base metal. Fuel gases do this by a "venturi" action that sucks powder out of a hopper. The brazing temperatures generated, permit either simultaneous spray deposit and "wetting"out - or pre-spray (to prevent oxidation) and subsequent "wetting out".



Oxy-Acetylene Gas Torch

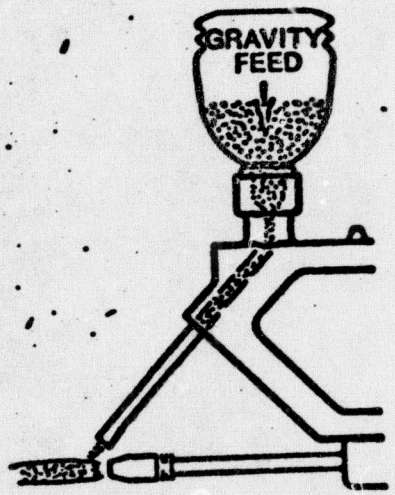
ADVANTAGES - Controlled precision overlay. All position deposit by rotating stem. Low capital investment.

DISADVANTAGES - Refillable hopper permits easy entry of contaminants that clog tips. Use of mixed gases to draw powder from hopper is EXTREMELY DANGEROUS. Mixed gases can easily back up into closed powder container when tip is clogged. Slight overheating and resulting popping in stem can then cause EXPLOSIVE IGNITION in the mixed cases that enter the hopper.

THE SHAFT "IMPROVER"

RoToTec represents a major improvement over all forms of "cold" process metallizing in terms of maintenance requirements. Powder is fed by gravity into the flame path. Comparatively low pressures are all that is required to propel powder onto the work surface. Surface preparation is simple and rapid. A thin bond coat is laid down first that effects a "true" weld without overheating. Subsequent build up alloys are selected for the specific needs of the application.

RoToTec Process Cold Application-
(2 step - Welded Bond Coat -
Then Build Up)

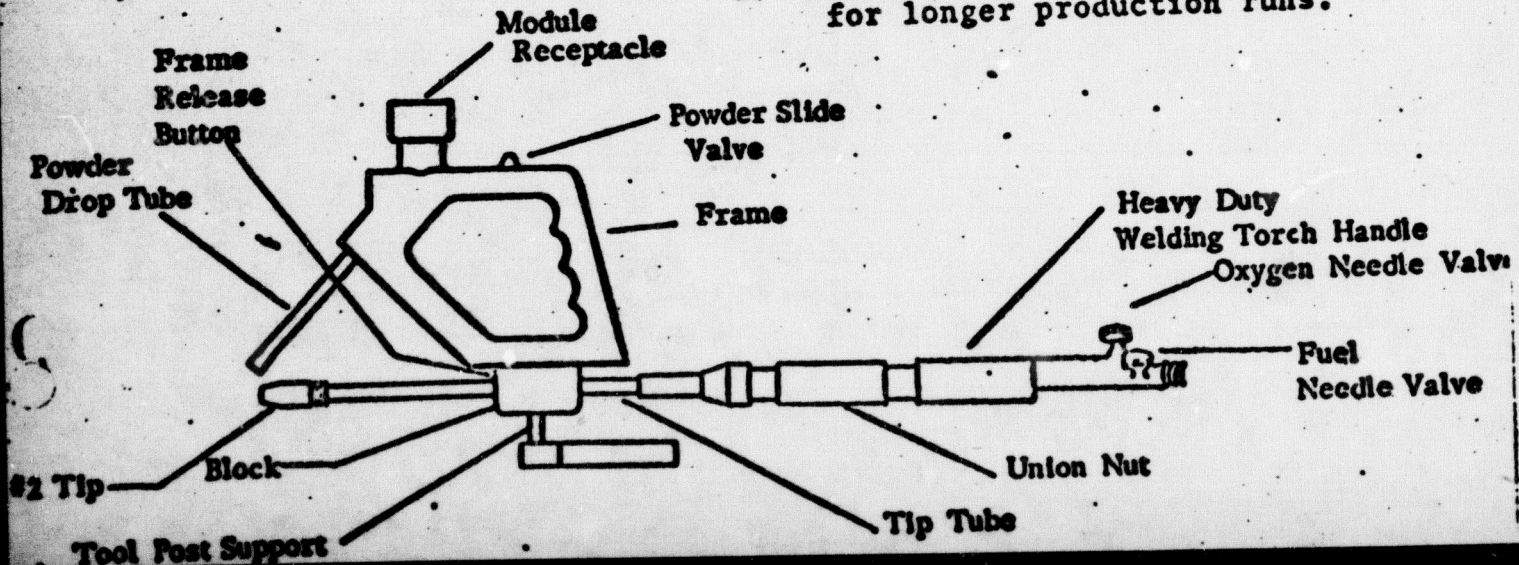


ADVANTAGES

a. ExoThermically applied bond coat - A true "weld" - with very high peel strength.
b. Wide margin for error in application technique.
c. Easy to learn and use
d. Very low set up time required.
e. All common shafting materials, even heat treated types, can be weld improved.
f. No moving parts.

DISADVANTAGES

a. Not sufficiently economical for longer production runs.



This is the RoToTec Gun

Designed for Immediate Use...

- No compressed air!... just standard oxyacetylene fuels!
- No flow meters! • No special welding skills!

Designed for Fast, Precise Repairs...

- No setup time! • Quick powder module changes! • Light and portable!

Designed for Long, Trouble-Free Use...

- Rugged construction...no maintenance! • No noise! • No odor,... no smoking or fuming! • No moving parts—powders are gravity fed!

ExoTec 29904
The Bond Coat Powder. Exclusive! Self-reacting exothermic powder forms the perfect base coat prior to all final coat spraying. ExoTec 29904 is the key to RoToTec's superiority. It produces the strongest, as-sprayed metallurgical bond to *every base metal* (except pure copper). It is the key to RoToTec's extraordinary reliability and effectiveness as a life-prolonging process.

DuroTec 19910
Final Coat Powder. A powder designed to produce a coating of higher hardness, requiring grinding for finishing operations. Especially recommended for bearing areas subjected to severe friction accompanied by *mild abrasion.*

LubroTec 19985
Final Coat Powder. Unique chemistry designed to produce tough, wear-resistant coatings for the use on a majority of parts. Coatings exhibit high internal strength and exceptional frictional wear resistance. Coatings are fully machinable with standard carbide cutting tools.

FrixTec 19850
Final Coat Powder. An extremely pure, bronze type powder. Designed for applications where bronze bushings and bronze bearing surfaces are desired. Coatings work-harden in service. FrixTec 19850 is easily machined with standard carbide cutting tools and yields a smooth, bright finish.

All RoToTec Powders produce coatings exhibiting the highly desirable characteristics of CONTROLLED PERMEABILITY. A network of microcavities accounts for approximately 6% of the total volume. These cavities serve as an internal reservoir for absorbing, retaining and releasing lubricant. This, in turn, permits a thin film of oil to protect the mating bearing surfaces in service...providing an additional factor for reducing frictional wear.

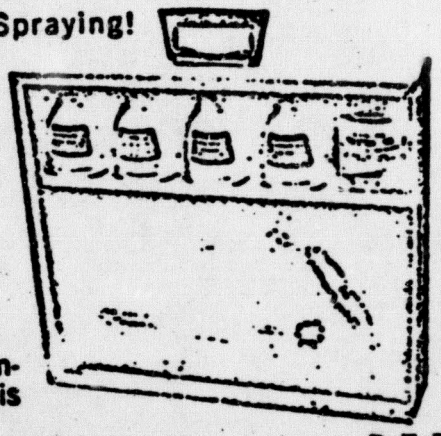
What's behind the success of RoToTec?

Two Things:

1. The ingenious simplicity of the RoToTec Gun, and...
2. The unique reliability of the EXOTEC bond coat powder.

Together, they can send your productivity and your profits soaring!
The RoToTec Process is the ultimate in simplicity. It's the ultimate in dependability too...because there's no opportunity for mistakes. It's also the ultimate in economy. The repair capability of one kit can easily save you three, four and five times the initial investment.
Once you see RoToTec Process, you will agree...no other similar method of repair comes close for maintenance needs.

The Revolution In Metal Spraying!

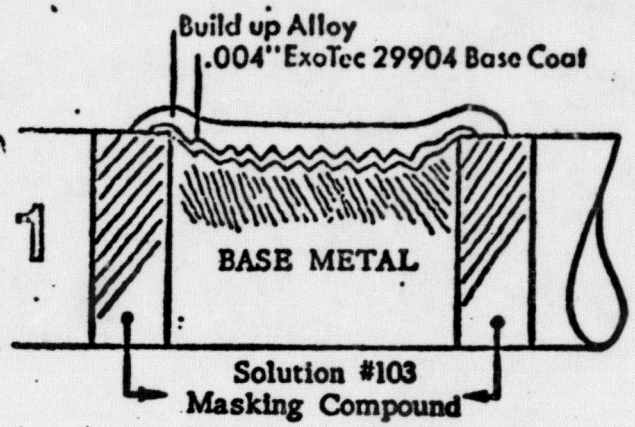


THIS KIT...
Can Be The Single, Most Important Tool You Use This Year!

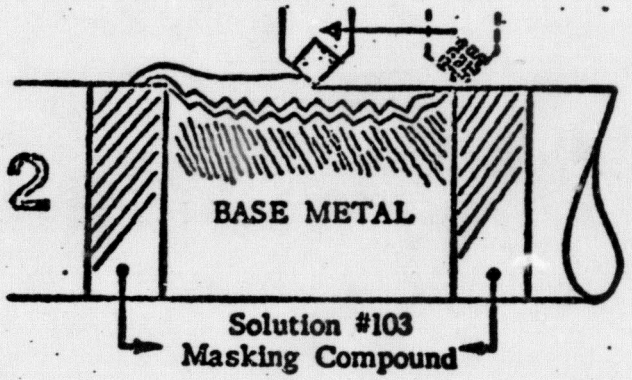
Every so often, old ideas and concepts wear out . . . just like parts! Take the words "Metal Spraying". It used to be thought of as a complex process requiring lengthy set-up time and expensive hardware, a lot of adjustments and readjustments of flowmeters, valves, wire feeds, etc., plus a vast amount of technical skill. It was noisy. At best, it produced only mechanical bonds and any slight variation, any deviation from any one of the many procedural steps might easily turn up as a coating failure. All that was *before* RoToTec...

Today...with a simple, easy-to-use RoToTec Kit, just about any shop, any machinist, any maintenance worker can get the most professional, long-lasting repairs on worn shafts, journals and bearings—repairs that used to require equipment costing many times as much plus the special skills of a highly trained "Metal Spray Technician".

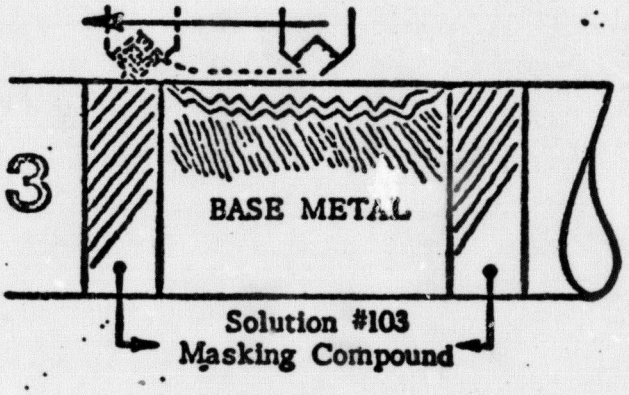
PROGRESS OF A RoToTec DEMONSTRATION



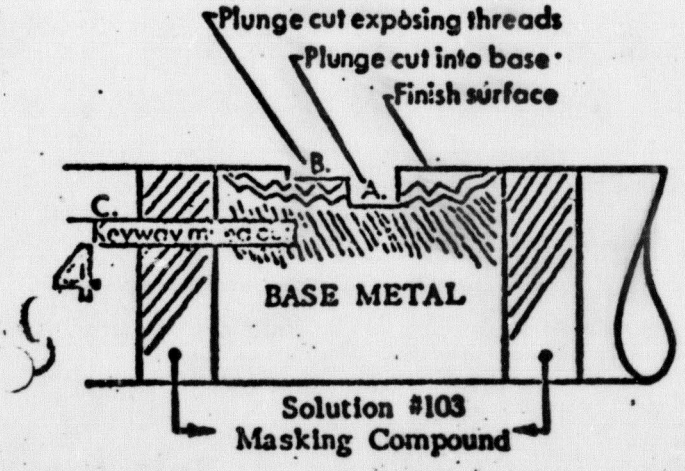
A Cross Section of a complete RoToTec Shaft repair prior to machining is whown here.



Machining should begin at either end of deposit and progress to other side. Ideally, this means removing approximately .005" to .010" per side on each pass. For testing or demonstration purposes, however, deeper (hogging) cuts can be made for more dramatic effect. Actual production needs may dictate cutting from centers outward, dependent on the application.

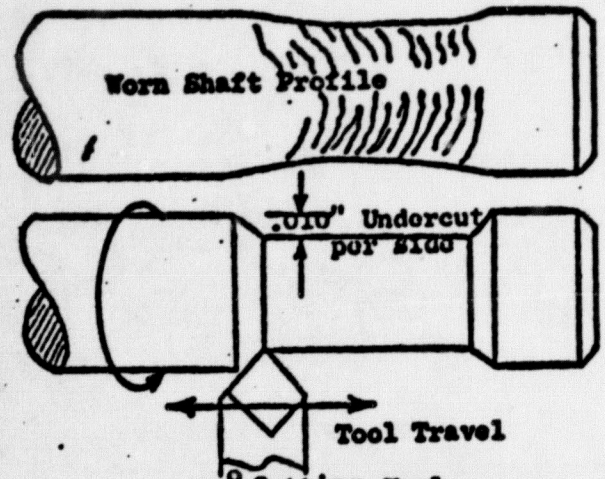


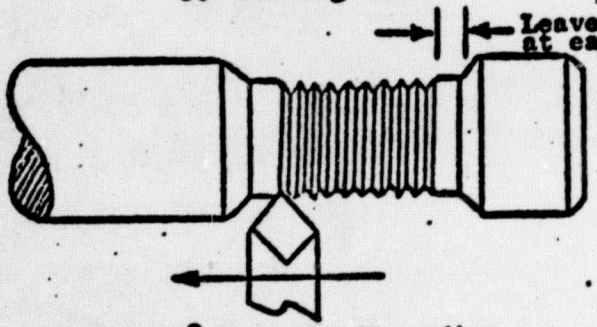
The beautiful appearance of the finished deposit should be pointed out. The user will also be glad to know that micro-porosities exist in the deposit for containment and controlled release of lubricants. This adds even greater life prolonging ability to the series of tough, low friction RoToTec overlays.



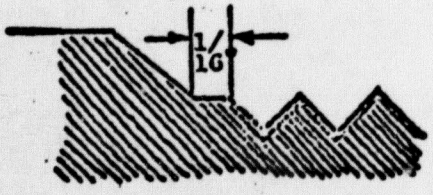
Here are some suggested tests of the holding power of RoToTec overlays:

a. Cut a groove rapidly into the base metal, about 3/8" wide.
b. Cut a groove deep enough to expose the threading, about 3/8" wide.
c. Mill a keyway slot from base metal and on into the overlay.
d. Peeling tendencies will not be found.
e. Eccentric or taper turning may also be used to illustrate the bond strength of deposit. Even "feather" thin ends, when so exposed, are there to stay!

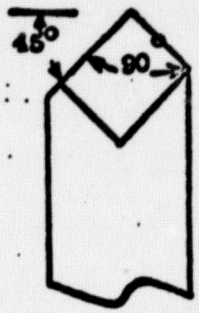


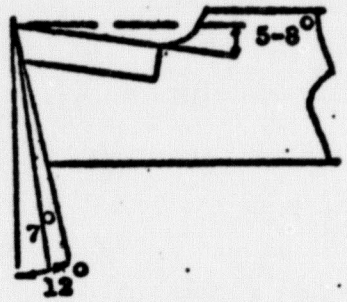


Same 90° Tool For Threading

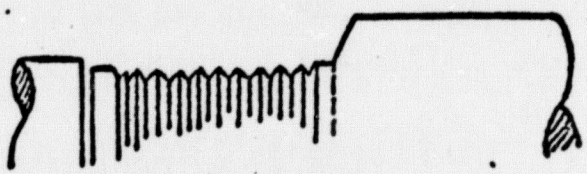


Cut "Visible" Threads Between 1/16" Lands. Approx. 30 to 70 TPI in a 2" to 3" Shaft Dia.





An Ideal Carbide Tipped Tool For Use In Both Surface Preparation and Finishing of RoToTec or Spram Deposits. Actually, carbide is only required for finishing and the 90° angle only for preparation. This suggestion saves machining time by not requiring tool bit changes.



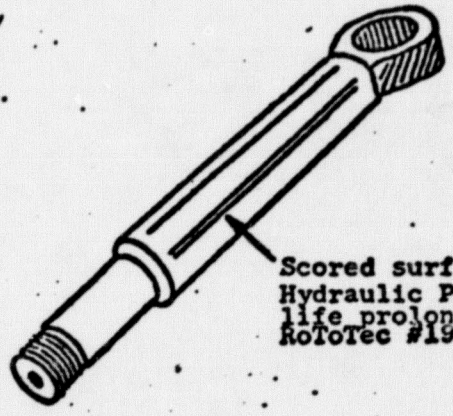
When Spraying Into A Shoulder

A - Open up Shoulder or
B - Tilt Torch Slightly Into Corner When Approaching or
C - Leave Small Radius In Corner
D - Continue Standard RoToTec Surface Preparation Procedure

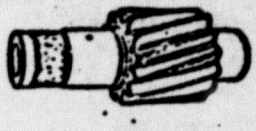
When Coating Must Extend to End of Shaft

A. No special requirements other than chamfering the ends are needed. This assumes a typical sliding wear service as the prime cause of wear
B. Continue Standard RoToTec Surface Preparation Procedure
C. Finish Machine As Required

RoToTec

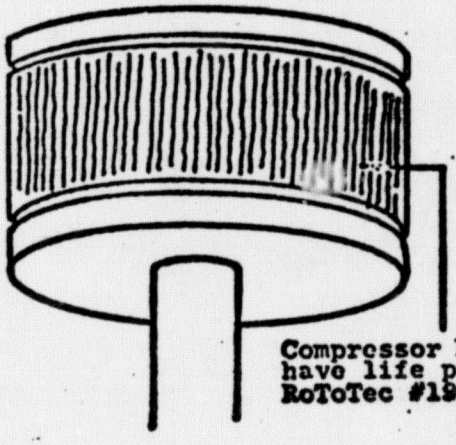


Scored surfaces on Hydraulic Pistons may have life prolonged with either RoToTec #19910

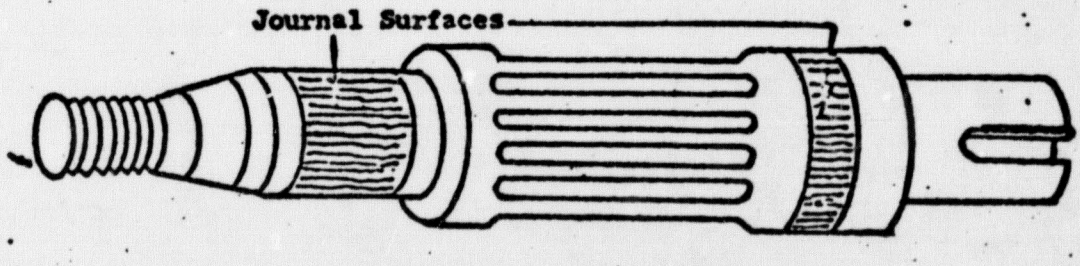


HOW MANY OTHER CYLINDRICAL PARTS CAN YOU FILL IN?

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____

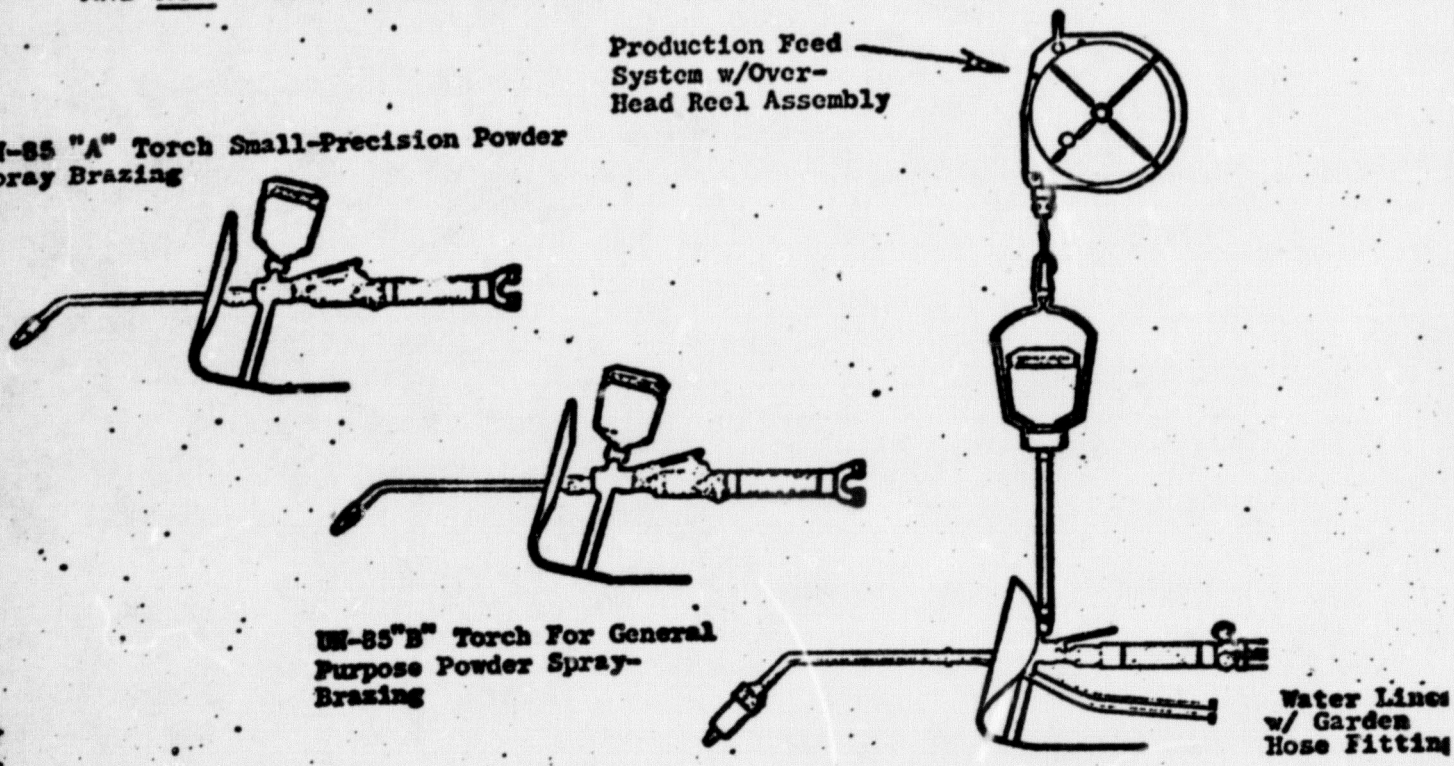


Compressor Pistons may have life prolonged with RoToTec #19850



Any and all shaped or sized shafts can have Journal Surfaces weld improved with cold process RoToTec

AND NOW - THE FAMILY OF POWDER PROCESSES DESIGNED FOR MAINTENANCE



Model UN-A

Usual use is touch up on edges of small tools, dies, molds and thin sections.

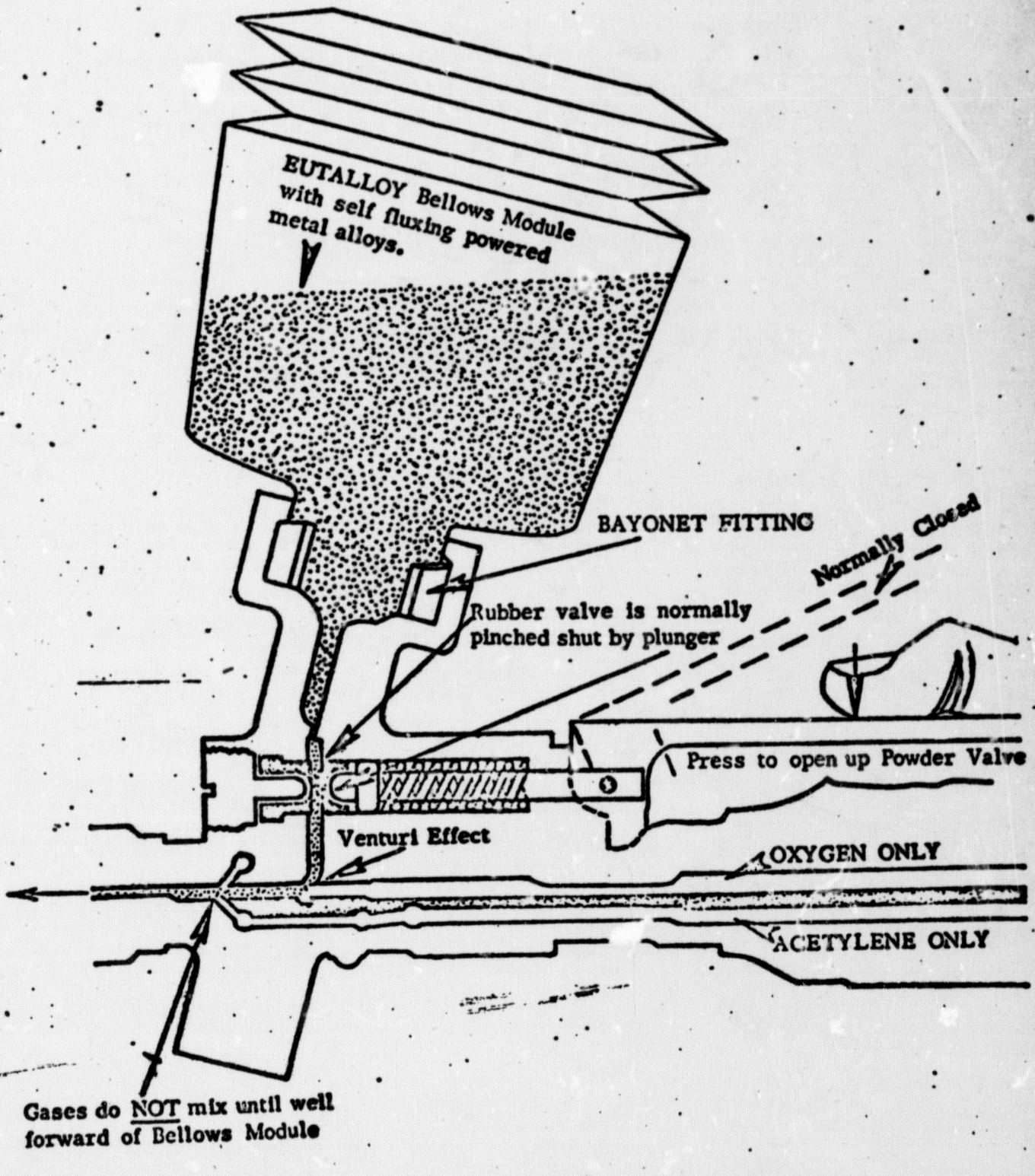
Model UN-B

Rebuilding of worn cams, gears, splines and keyway edges would be the typical applications. An excellent general purpose recommendation.

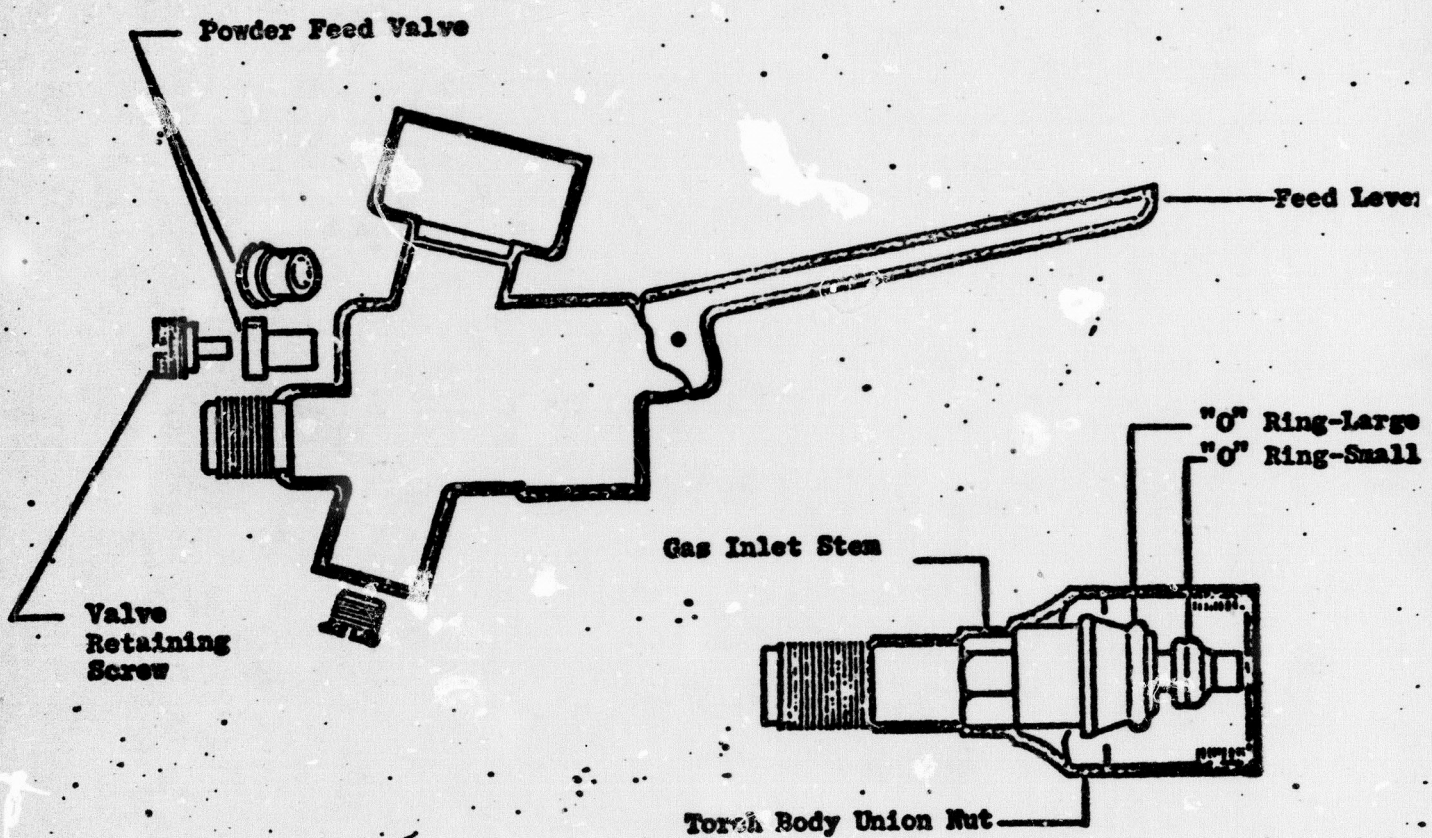
Model "C" Torch

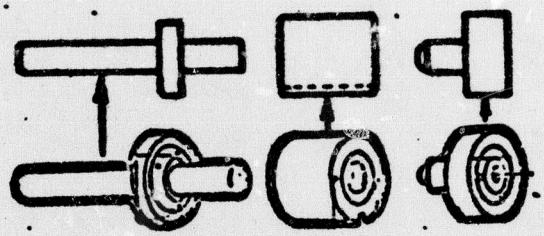
Rebuilding of gouges, machine ways, large gear teeth, pump and valve parts are typical applications. Also for confined areas where radiated heat is a problem.

ADVANTAGES - All Eutalloy Torch Sizes - Precision application of wide range of powders to almost all Ferrous and many non-ferrous metals. Deposits as thin as .004 or up to 1/4" per pass under full visual control. Minimum learning time required. Since powder pickup is by oxygen only, explosion hazard is effectively non-existant. Disposable powder container is functional part of system. This prevents entry of clogging contaminants. Bellows action boosts positive feeding. Bayonet fit of bellows module permits rapid change.


EUTALLOY Bellows Module with self fluxing powered metal alloys.
BAYONET FITTING
Normally Closed
Rubber valve is normally pinched shut by plunger
Press to open up Powder Valve
Venturi Effect
OXYGEN ONLY
ACETYLENE ONLY
Gases do NOT mix until well forward of Bellows Module

ASPIRATOR ASSEMBLY: Exploded View





Gas Mixer

Oxygen Injector

Aspirator

THE POWDERS

There are many many different types of powders. In order to classify them, they have been graded or numbered. In our line by their special alloy chemistry and/or their maintenance application.

SOME EXAMPLES ARE LISTED BELOW:

Chromtec 10680	Keyways, bearing surfaces, idlers, impellers, collars	Best machinability on steel High strength Ideal "cushion for single-pass harder overlays HARDNESS RC 10-15 TENSILE STRENGTH 75,000 PSI
Diamax 10999	Fan blades, cutting knives, screws, chains, feed rolls	Optimum friction/abrasion resistance Resists spalling and scoring Smooth deposits that polish in service HARDNESS: RA 80-85
Borotec 10009	Cams, guides, feed rolls, bearing surfaces, wobblers, fan blades, patterns, dies, tools	Excellent resistance to metal-to-metal friction Resists galling, scoring, seizing Retains high hardness at elevated temperatures HARDNESS RC55-62
Eutallite Universal 10092	Valves, furnace parts, piercing dies, plating baskets, pickling hooks	Resists softening and scaling at high temperatures Excellent corrosion-resistance Hardness stability Good combined abrasion/frictional wear resistance HARDNESS: RC 45-50
Nitec 10224	Machine bases, pump housings, gear hubs, hydraulic cylinders, gear boxes	Best wettability, machinability on cast iron Deposits are smooth, dense and machinable High resistance to heat scaling, impact and corrosion High ductility
Tungtec 10112	Augers, wear plates, cultivator sweeps, scrapers, debarkers, die frames, screws, tire chains	Tungsten carbide hardness Outstanding abrasion-resistance Excellent edge-retention Superior resistance to such abrasive media as sand, gravel, cement, etc. HARDNESS RC 57-64 (combined hardness of evenly distributed tungsten carbide particles in nickel-base matrix)

Bronzochrom 10185	Gear teeth, bearing surfaces, impellers, pulleys, keyways	Best combined hardness/machinabiltiy Superior toughness Unlimited build-up capability Low friction, high wear resistance HARDNESS RC 36-42

TWO TYPES

There are two different ways of producing powders. One is a low cost way and very simple, while the other is very elaborate and consequently mor expensive to produce. They are:

1. Crushing Powders
2. Atomizing Powder Process

CRUSHED TYPES

This manufacturing method is similar to that of a rock crusher. Once the desired alloy has been selected, it is merely crushed-down to small sized grain.

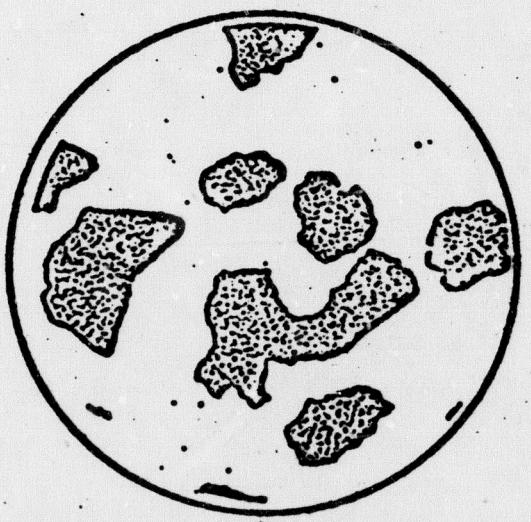
The big drawback here is that the grains are not uniformly shaped. Some may be on the long side (like a sliver of wood) or somewhat irregular round (like coal) while others are simply indescribable. Their hard and sharp edges also cause erosion of internal working surfaces of the special torches.

Another drawback of crushed types is that corners oxidizing readily due to overheat, and harmful oxide inclusion get trapped in the weld. Contaminations from crushing operations are also harmful.

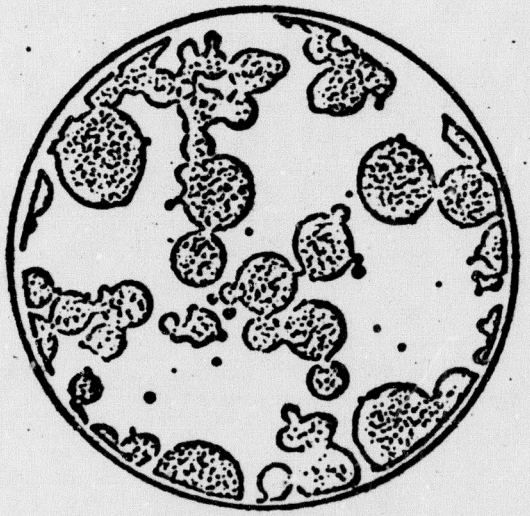
ATOMIZED TYPES

As I said, this type is very much costlier to produce and requires a constant vigil and a high level of quality control in order to produce a desired and wanted effect. Cleanliness - control of particle size, less oxidation during application are some of the advantages.

Here are magnified photomicrographs of the two types, magnified 250 times. It's easy to see the difference between the grain shapes:



CRUSHED



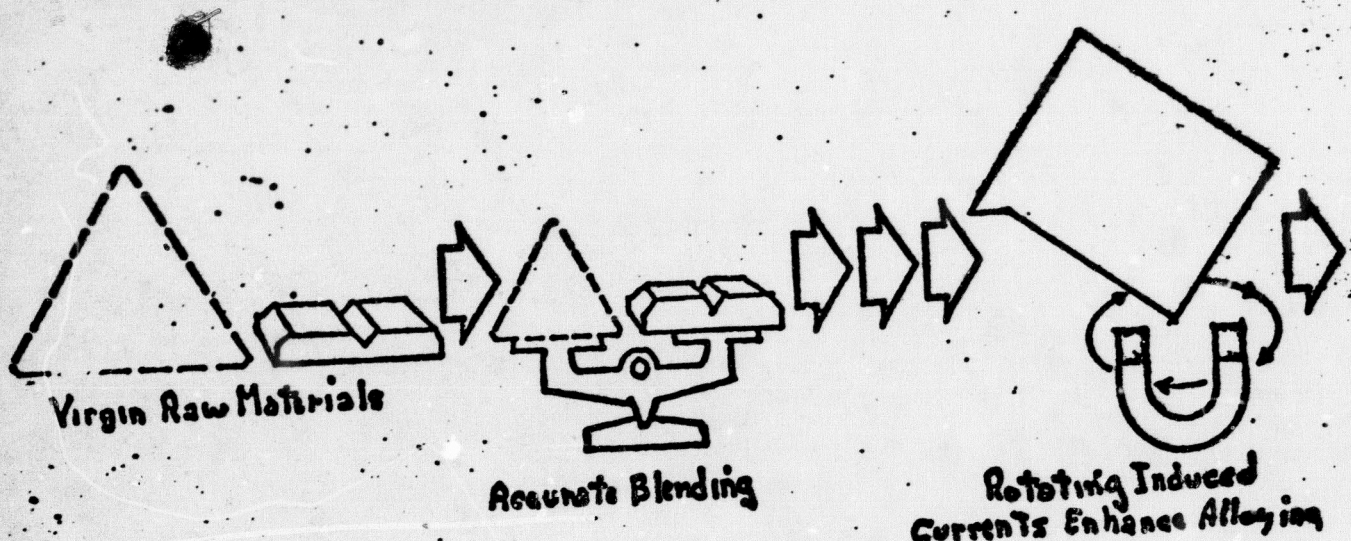
ATOMIZED

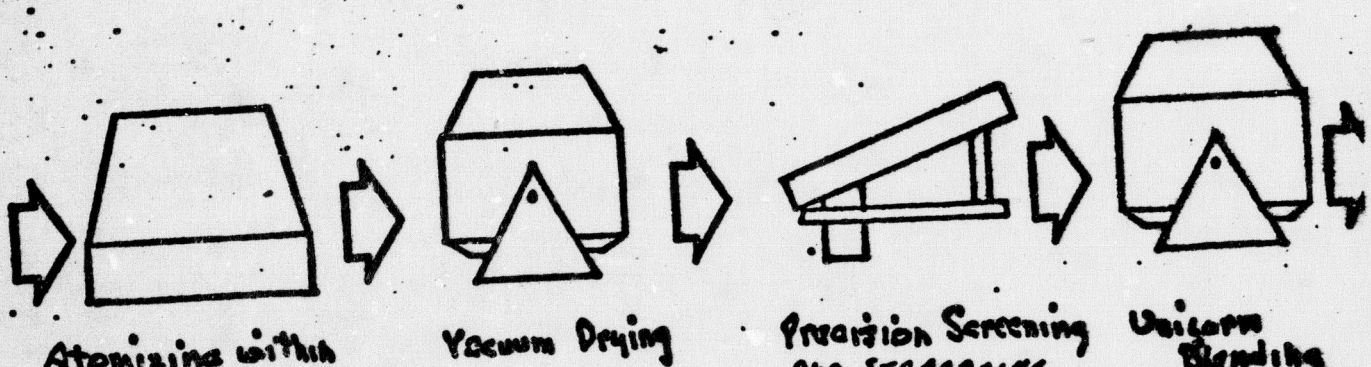
Even an ordinary magnifying glass will readily tell you if the powder that you are using is the crushed type of the atomized type.

From raw materials to finished product,

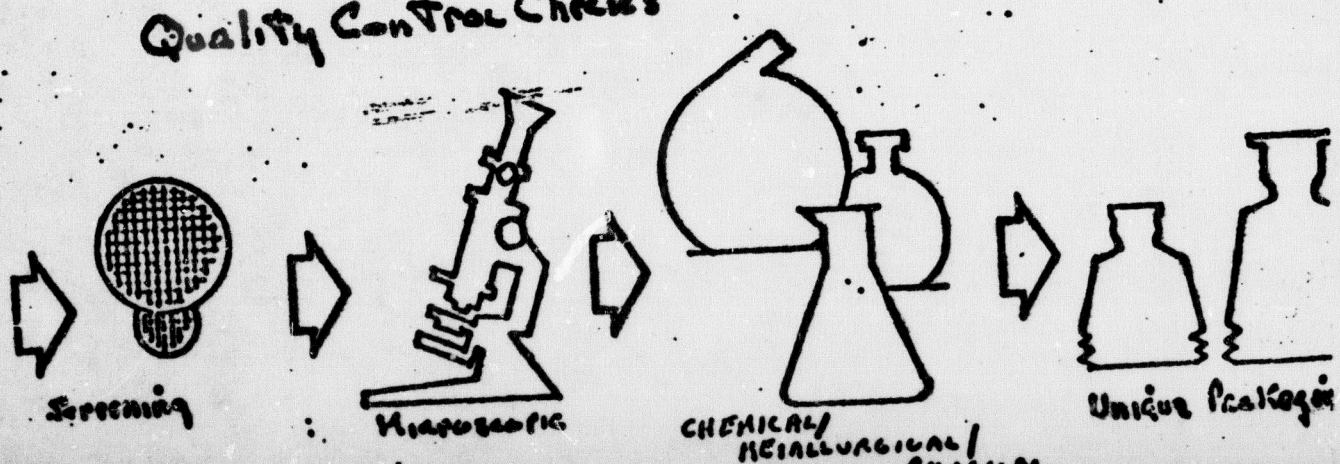
Precision alloying of virgin materials is done by rotating induced currents. Both melting and atomizing are performed in an inert atmosphere, eliminating any possibility of oxide formation during all manufacturing steps. Manufacturing procedures are quality-controlled and tested at all stages to insure the ultimate in performance.

E 122





Quality Control Checks



POWDER CONTAINERS

Conventionally, most powders are marketed in 2, 5, and 10 pound cans. The torch comes equipped with a little funnel attached to the top of it. The contents of the can are poured into this little funnel and welding begins. You would not believe the problems that this system created.

1. In order for the torch to "breathe" a small hole was drilled right on the tope of the cover over the little funnel container. If the welder was not very careful and he tipped the torch over slightly, the powder ended up on the floor instead of on the work.

2. When the job was finished, the welder would pour the powder back into the cans. But if he had been using two or more types of powder on one job (a soft powder and a very hard one) chances of his pouring unused powder into the wrong can became an everyday occurrance. Can you imaging a machinist asking a welder to deposit a soft powder on a part that had to be machined, and without knowing it, the welder has poured the very hard powder into the wrong can the day before???

3. Another problem is one of accidental moisture or dirt pick-up during this pouring - un-pouring saga. The smallest amount can cause all kinds of jamming and blocking of the torch.

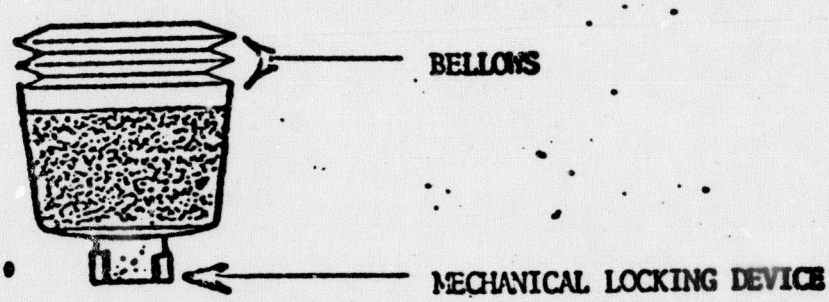
Let's face it, a better system was needed, and in the early 1960's it was decided to introduce a new container that would fit directly on the torch. These are called....

BELLOWS MODULES

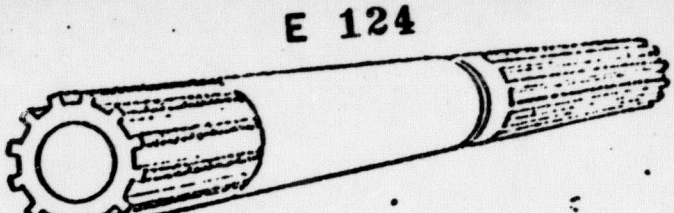
MEANINGS: BELLOWS is a part that has been pre-designed for the purpose of being able to open and close like the action of hand bellows used to stimulate flames in a fireplace or forge. It has the ability to "breathe".

MODULE is a self-contained unit like that of a spacecraft.

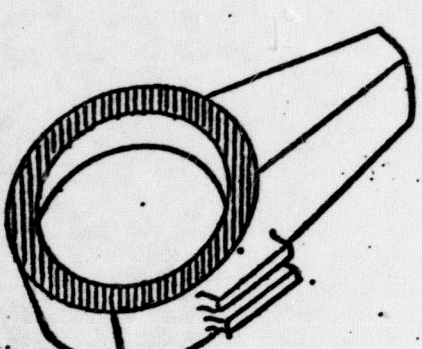
Because they are made of plastic, they are relatively inexpensive and thus can be disposed of after they are empty. They look like this:



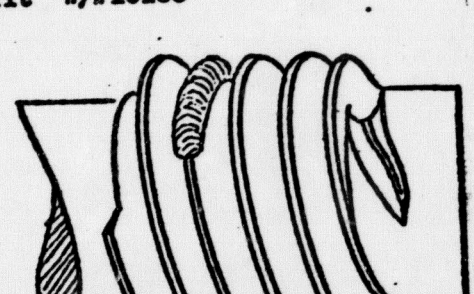
DRAWING OF AN "INVERTED"
BELLOWS MODULE WITH POWDER.



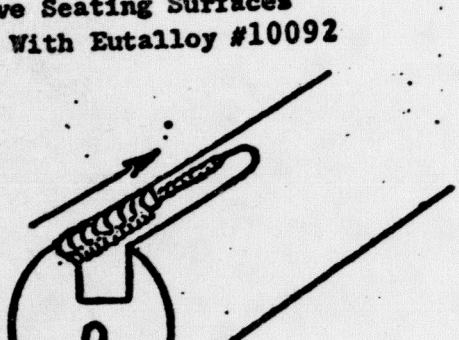
Splines Rebuilt W/#10185



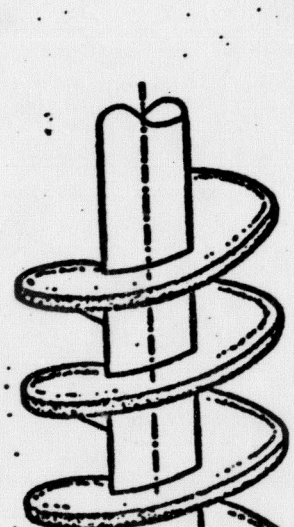
Gate Valve Seating Surfaces
Overlaid With Eutalloy #10092



Worn Or Chipped Threads
Rebuilt With #10680

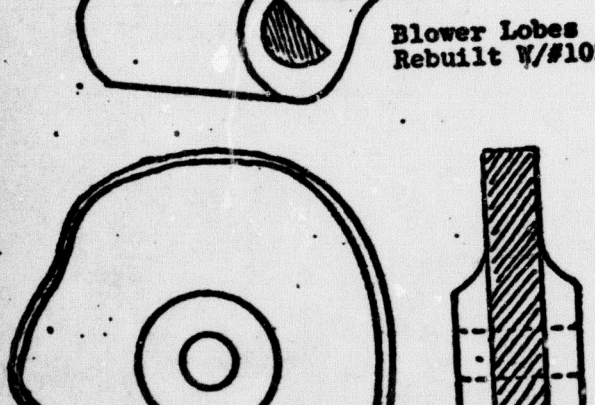


Battered Keyway Edge Rebuilt
In Place W/#10680
Can Be Finished By Hand Filing.

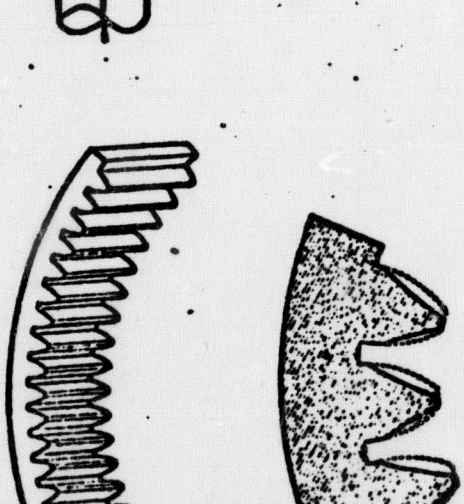


Screw Conveyor Flights.
Augers, Expellers, And
Extrusion Screws Can Be
Rebuilt W/#10009 or 10112
or 10999

Blower Lobes
Rebuilt W/#10224



Tho Hard And Slick Surfaces Deposited
By Eutalloy #10009 Are Ideal For
Canning Applications

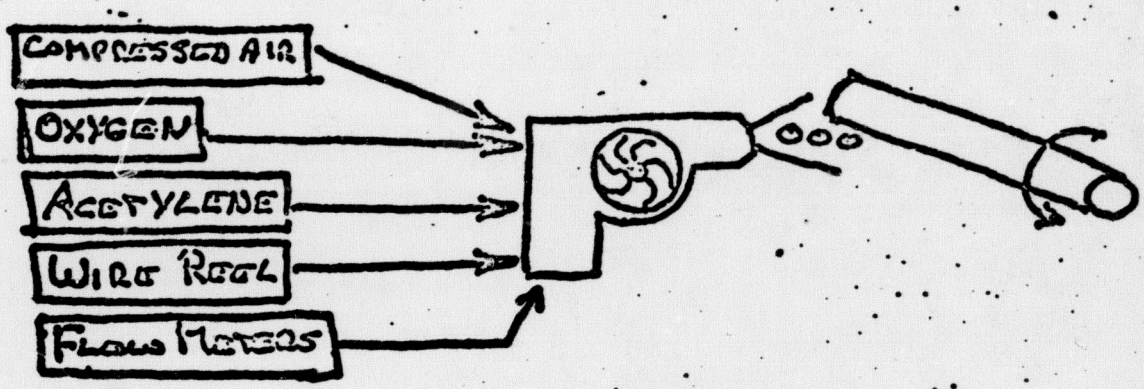


Gear Tooth Rebuilt W/10185

BLACKBOARD NOTES

In the event slide presentation, flip chart, or other visual aid not available, these simple sketches and notes will make an effective "chalk talk"

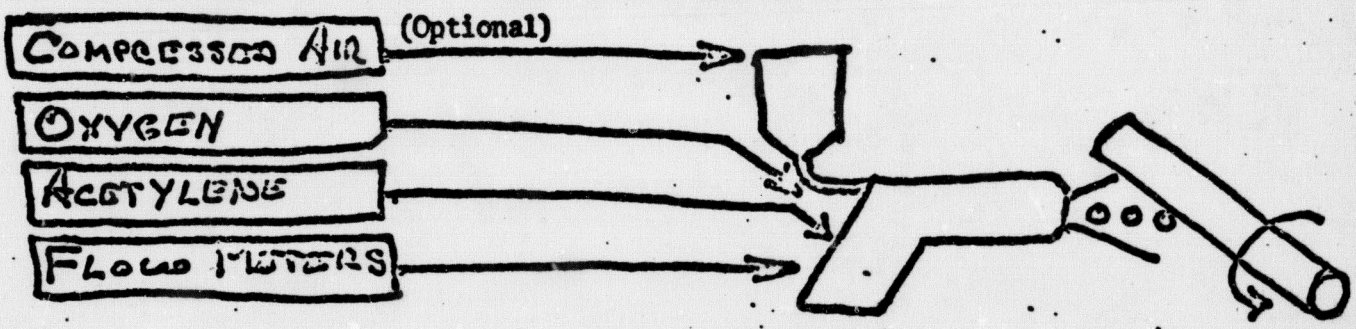
1. WIRE METALLIZING - 1 or 2 WIRE APPLICATION METHODS



Expensive
Complex
Noise - Odor
Extensive Surface Preparation
Time Consuming Set Ups
Not for Severe Impact
Nozzle Wear

Low Temp.
Flat Applications - Corrosion Coating
Economical - Production Qty only

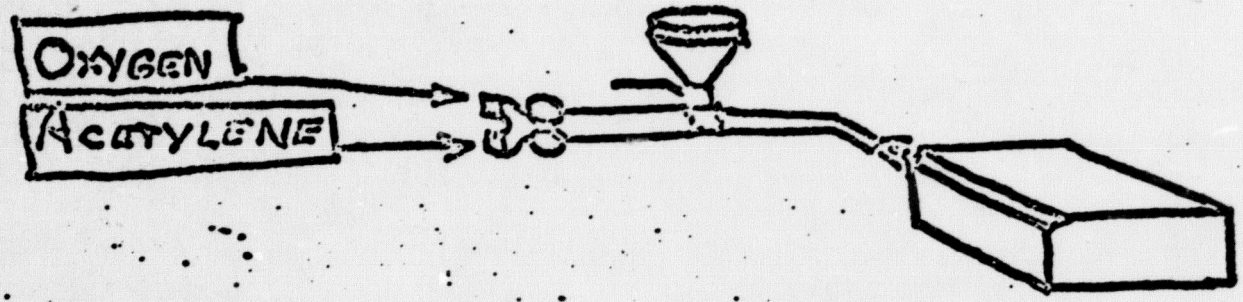
2. POWDER METALLIZING - BOND COAT & BUILD UP*



Expensive
Complex
Not for Severe Impact

Versatile - Metallic & Ceramic
Low Temp.*
Spray & Fuse capability (Hot Process) w/self fluxing powders
Economics Favor Production Use

3. PORTABLE SPRAY - BRAZING - HOT PROCESS

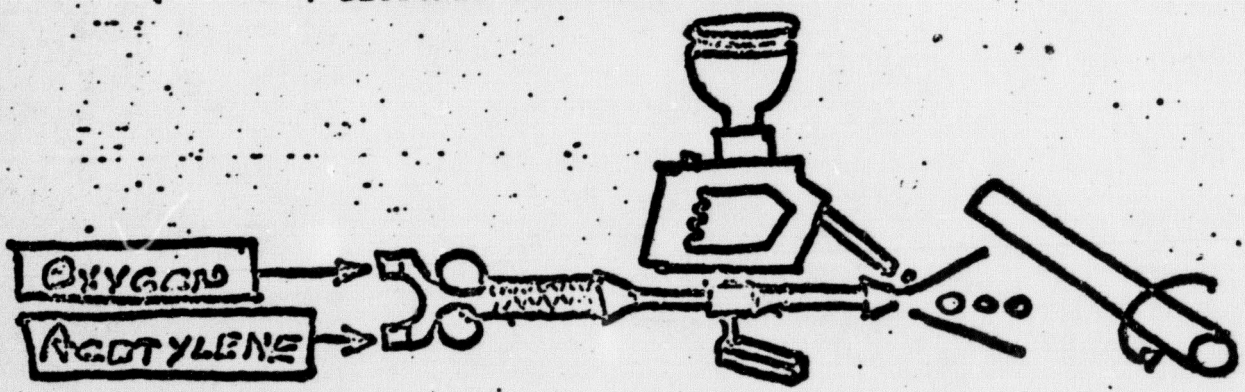


Portable
Inexpensive
Convenient

Poor Operator Control
Hazardous
Powder Mixups - Clogging
Hot Process Only

4. ROTOTEC - BOND COAT & BUILD UP

DESIGNED FOR MAINTENANCE

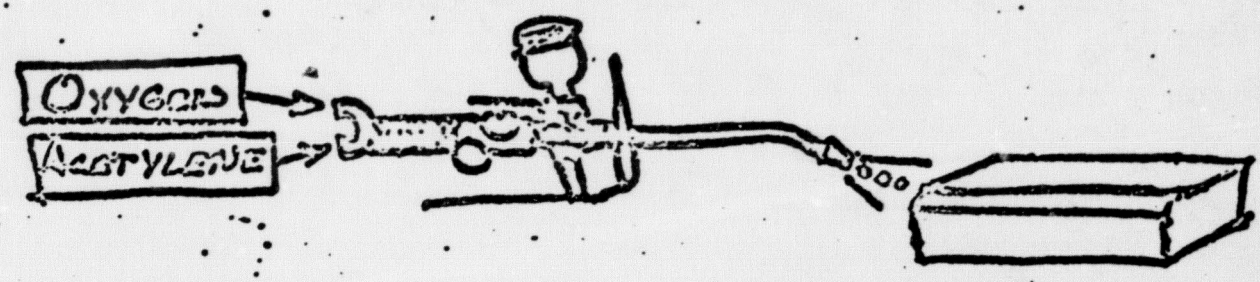


Inexpensive
No Moving Parts
Practical/Effective
Rapid-Easy set up
Low Temp.
Metallurgical Bond.
Quiet - Odor free

Not for Severe Impact or abrasion
Production Economics Limited

5. EUTALLOY - SIMULTANEOUS SPRAY & FUSE

DESIGNED FOR MAINTENANCE



"Hot" Process only

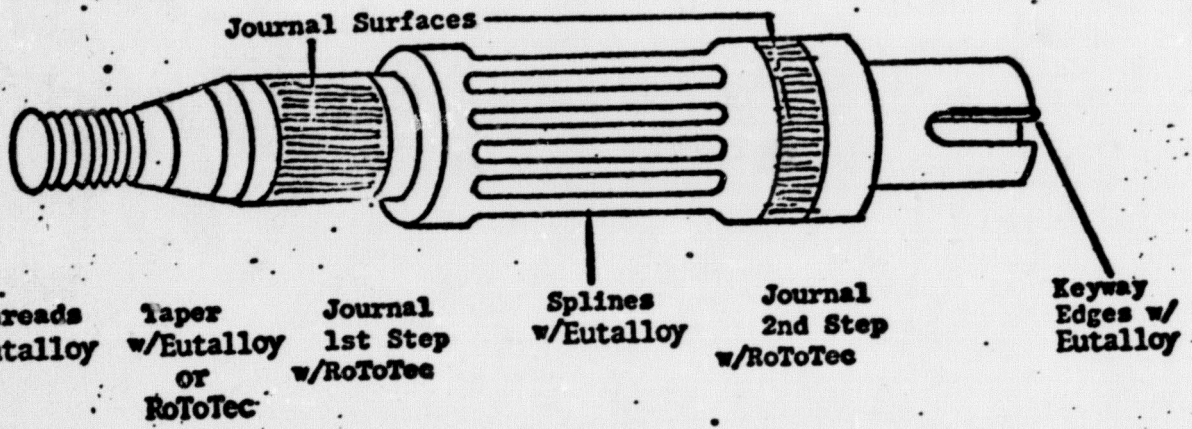
Inexpensive
Convenient
Portable
Simple/Safe
Effective/Practical
Excellent Operator Control
Largest Variety of Available Alloys

6.

SHAFTS	GEARS	PUMPS	VALVES
Tapers	Teeth (surface)	Impellors	Gates
Keyways	Teeth (entire)	Housings	Seats
Splines	Spokes	Shafts	Stems
Threads	Hubs	Linings	Housings
Shoulders	Housings	Seals	Plugs
	Pinions	Couplings	Flanges

BASIC SHAFTING EXPERTISE

A "shaft" is simply a device by which turning force or "torque" - can be transmitted from a "driver" machine (motor, turbine, engine, etc.) - to a "driven" machine (pump, fan, gearbox, etc.). The two machines may be mounted on the same shaft, or they may have their own shafts and be tied together by a mechanical coupling.



JOURNAL SURFACES - These are the areas that turn within a ball, roller, sleeve, or other type bearing. Surface gouges or grooves are caused by galling wear from lubrication failure, or abrasion by dust and grit. Proper weld rebuilding can actually improve on the original. RoToTec is the preferred method for journals.

KEYWAY - When keyways of both driver and driven machine are lined up, a solid, long square "key" is inserted through both keyways in the shafts and the corresponding keyways in the coupling. This locks the two shafts together. Keyways may also be used to mount a gear or cam on a shaft. When keyway edges become battered, they must be rebuilt. Eutalloy is the preferred method of repair.

TAPER - When pressure is exerted against mating tapered surfaces a wedging action takes place. This permits torque to be transferred without slippage, yet permits easy separation of the two surfaces. When surfaces become spalled or worn, contact area is lost and the driving force cannot be transmitted properly. In some shaftings, tapered roller bearings reduce friction on a tapered shoulder in order to relieve thrust forces while reducing rolling friction. In most cases RoToTec is the preferable repair method.

THREADED ENDS - Provide a means for screw mounting many parts on the output end of a driver shaft. Such items are further locked in place by a nut and washer, or cotter pin assembly. The wheels of your car are held on this way. Many such axle shafts also have a tapered shoulder. Eutalloy is an ideal method for rebuilding chipped or worn threads.

SPLINES - In effect, a series of parallel keyways. A gear that is spline mounted may be moved lengthwise along the shaft without radial slippage - until wear occurs. An automobile transmission has several splined shafts in the transmission so that you may "shift gears". Eutalloy is the preferred method for repairing spline surfaces.

SHOULDERS & STEPS - Changes in diameter are necessary in many designs for assembly and mounting purposes. When new shafts are made without any steps, bar stock may be purchased with pre-finished diameter. This may be cold rolled, cold drawn, or turned-ground-and polished (TGP) bar stock. If only a small central portion is of maximum diameter, it is more economical to start with hot rolled bar stock since you must machine off most of the surface anyway.

MAINTENANCE WELDORS NEED TO CONCERN THEMSELVES WITH THE FOLLOWING:

Low, Medium or High?

Is it a Straight Chrome Stainless?

4130 and 4340 are common in recent years. SAE #1045 on old line shafting.

LaSalle & Republic Steel Specialties are #1330 cold drawn

8620 is an Example

CARBON CONTENT (over .20 Carbon can cause unintended hardening if hot processes are used.

ALLOY CONTENT (Carbide precipitation, warpage or unwanted hardening may result w/hot processes or poor procedure)

HEAT TREAT HARDNESS, IF ANY (may cause weld failure w/hot processes as in medium carbon and alloy shafts)

SURFACE WORK HARDENING (Can cause workage as in cold drawn or cold rolled)

SURFACE TREATMENT, IF ANY (must b removed before welding as in nitrided or carburized shafts)

SHARP CORNERS at steps and shoulders that concentrate stresses.

WHAT CAUSED PROBLEM - Not strong enough, tough enough, not slick enough, not hard enough, cyclic fatigue, lack of lubrication, high or low temperature operation, corrosive action, abrasive action, etc.

WERE ORIGINAL PROPERTIES good enough for service conditions.

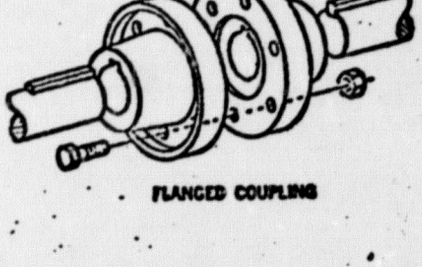
WHAT ALLOY & PROCESS selection will prolong life

COMMON BASE METALS USED IN SHAFTING

1020 - Simple cold rolled steel. Hot or cold processes OK.
B1112 - Re-sulphurized free machining steel. Cold process preferred.
B1214 - Re-sulphurized and Re-phosphorized free machining steel. Cold process preferred.
B12L14- Re-sulphurized, Re-phosphorized, and Leaded free machining steel. Cold process preferred.
1330 - Cold drawing grade work hardened to high strength. Excellent for tough threads also.
1040 - Medium strength low cost shafting. Common in older line shaftings.
4140 - Popular heat treatable "chrome-moly".
4340 - Popular heat treatable "nickel chrome-moly".
8620 - A low carbon "nickel-chrome-moly" whose surface readily accepts case hardening by carburizing or nitriding.
304 (or 302 or 308) - Most common stainless types.
303 - An 18-8 type stainless w/Selenium added for extra machinability.
316 - An 18-8 type stainless w/molybdenum added for extra acid resistance
440 - A straight chromium stainless steel that is heat treatable.
17-4PH - A highly hardenable high strength grade.

COUPLINGS

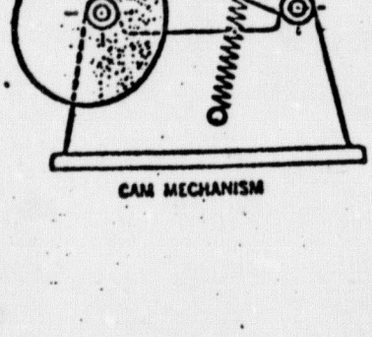
A coupling is a device that connects two shafts end to end, while a clutch is a coupling provided with some form of sliding or other arrangement whereby the shafts can be connected and disconnected at will.



FLANGED COUPLING

CAM MECHANISM

A cam is a specially shaped component that serves to guide the motion of a component called a follower. The cam may have a linear or a rotary motion. Like the crank mechanism, the cam mechanism serves to convert a given input motion (usually a uniform motion) into a desired output motion of particular form. With a crank mechanism it is not always possible to produce a motion whose path is of the desired shape, whereas a suitably designed cam mechanism will make possible practically any shape or pattern of motion. A great advantage of the cam principle is that it is quite conveniently possible to introduce pauses of any desired length into the motion. This advantage is widely utilized in machinery of all kinds, such as packaging machines and many others. With cams it is possible to perform simple oscillatory or sliding movements as well as precisely controlled movements of elaborate shape (e.g., guiding a milling cutter along a curved outline of any desired shape).

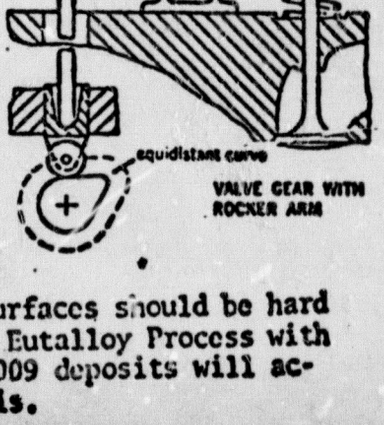


CAM MECHANISM

CAM MECHANISM WITH FOLLOWER AND ROLLER

GLOBOID CAM MECHANISM

CAM MECHANISM WITH LEVER-TYPE FOLLOWER



VALVE GEAR WITH ROCKER ARM

Cam Plate Surfaces should be hard and slick. Eutalloy Process with DeroTec #10009 deposits will accomplish this.

Sometimes a maintenance machine shop will maintain a stock of bar steel so that they can make their own replacement shafts. We've noted that they wisely prefer to use better grades of steels than OEM materials for this purpose. Accordingly, we've worked out an interesting cost comparison for a worn journal problem on a 3" dia. shaft of simple shape. Assume a straight shaft - 24" long with a keyway at one end and a short thread at the other end. There are two journal surfaces of 2" length that are heavily scored. Our own purchasing department advises that an OEM part made of heat treated chrome-moly steel would cost about $200 as a spare part purchase from an equipment manufacturer.

Bar steel of 3" dia. either cold drawn, cold rolled, or TPG finish would be selected. This weighs 24 lbs. per ft. A steel supplier will usually sell only a 10/12' half random length as a minimum and prefers selling a full random length bar of 20 to 24 feet. A total weight of 500 lbs. is typically in the bar rack.

A pre-heat treated - TPG bar of premium quality alloy steel sells frequently for $.50 lb. or $250 for a full bar. To get a 2 foot long 50 lb. piece (worth $25 for steel only) you manhandle the long bar to a power hacksaw - cut your length and return the balance to the bar rack. At least $25 in labor and machine time has been added.

You then mount the cut length in the lathe and machine the required threads. Another $25 in labor and machine time has been expended.

The part then travels to the milling machine where another $25 may be invested in producing a keyway. At this point, we can begin to add downtime costs and assembly/disassembly labor. But first, we <u>may</u> have made a better shaft for half the price of a new one. Oops? I almost forgot the cost of keeping the long bar in our inventory!

A better choice would be in bringing the paid for (but worn) shaft to the lathe. For under $50 in labor and materials we can rebuild the worn journals with RoToTec. Not only is the price right, but the rebuilt surfaces will long outwear our other options!

WHAT ARE GEARS MADE OF:

Mechanically - They may start life as one of the following:

A. A casting
B. A forging
C. A disc sawn from a cylinder
D. A disc flame cut from a plate

Chemically - They may be of low carbon mild steel but, if worth repairing the following list is more likely:

Grey Cast Iron
Low Alloy - alloyed cast iron such as Meehanite or Nodular - Medium Carbon Cast Steel - Chrome-Moly Types
Low alloy medium carbon forged steels - Chrome-Moly Types
Case hardening chrome moly grades in cast or forged forms
Leaded Bronze alloys - Pouplar in worm gear sets
Aluminum bronzes
Silicon bronzes

How are teeth produced:

By milling of low quantity simple spur or helical shapes -

These can obviously be easily finish machined after weld improvement.

By Hobbing -

A form of high production milling. Here again maintenance weld repairs can be effected to spur and helical shapes.

On a special gear generating machine (Gleason Type) -

Complex shapes such as spiral bevel or hypoid gearing have curved teeth. If the customer cannot arrange recruiting after buildup of a complete tooth - he won't attempt the repair. A simple overlay with Eutalloy to a worn tooth facing may not even require finishing.

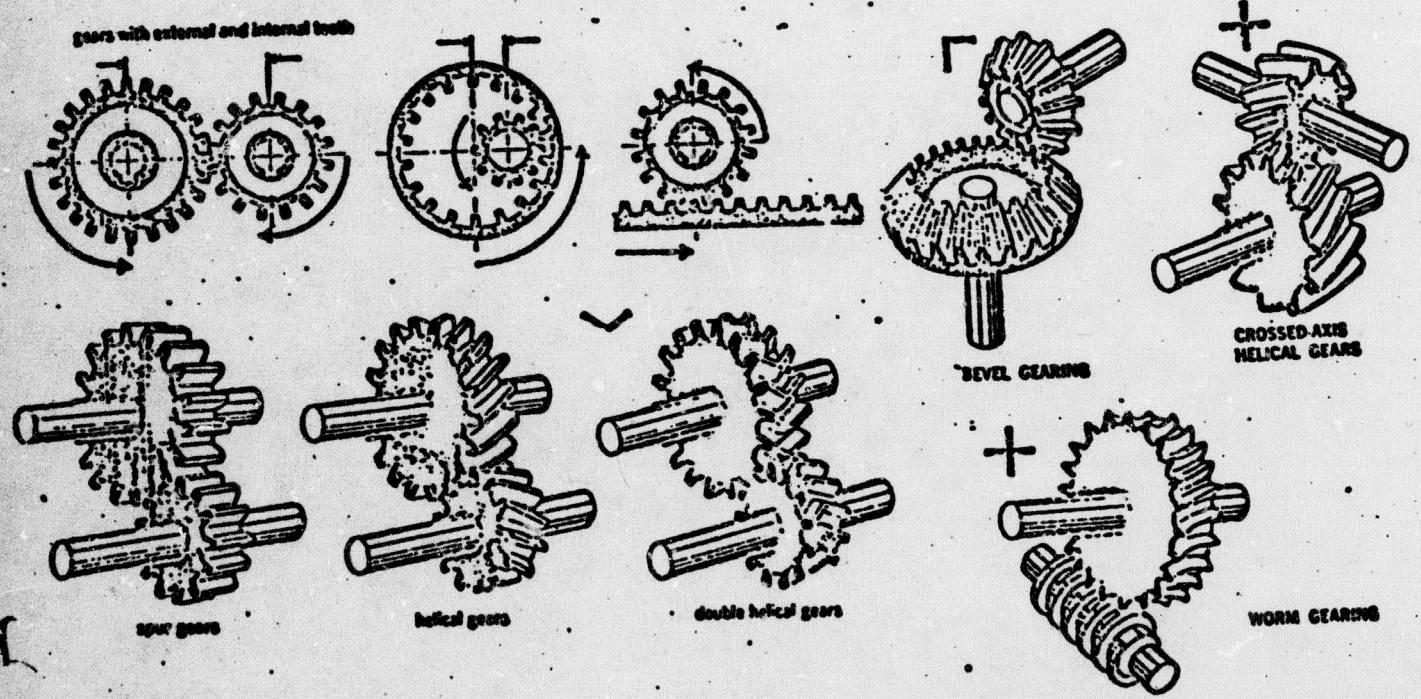
What can a maintenance repairman do -

By making a template from a sound tooth, duplication by hand filing, hand grinding, use of a shaper, or milling machine - spur or helical teeth are frequently easy to repair - with Eutalloy precision deposits. Curved tooth forms are possibly impractical if extensive rebuilding and precision finishing is required.

GEARS

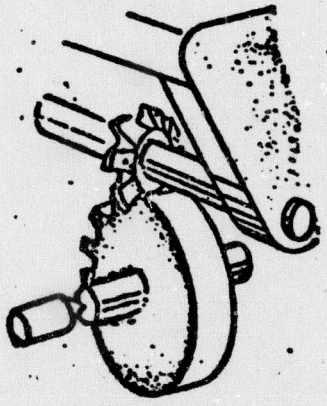
Toothed wheels whose teeth mesh with one another and which serve to transmit rotary motion or power from one shaft to another are called "gears". The smaller of a gear pair is more particularly called the "pinion" and the larger is the "gear".

Parallel shafts may be connected by spur gears, the simplest and commonest type, with teeth that are parallel to the axis of rotation. In the case of helical gears, the teeth are inclined in relation to the axis. This ensures smoother and quieter action and better load capacity, but there is the disadvantage that the teeth set up a side pressure which causes thrust on the bearings. To overcome this, double helical gears (or herringbone gears) may be used; these have teeth of V formation, so that lateral thrust is compensated. Rack-and-pinion gearing comprises a pinion with a straight toothed bar (the rack); this arrangement enables rotary motion to be converted into longitudinal motion, and vice versa. Bevel gears are employed in cases where the shafts form an angle with each other. If these shafts are at right angles, such gears are called miter gears. To obtain more efficient meshing, bevel gears may be provided with spiral teeth instead of straight teeth and are then known as spiral bevel gears. If large forces have to be transmitted, worm gearing may provide a suitable solution; one of the gears is called the worm and the other the worm wheel (or simply the "gear"). The worm is of helical shape, forming a continuous "tooth"; the worm wheel has independent teeth and is driven by the rotation of the worm with which it meshes.



GEAR CUTTING

Most metal gears for precision work are produced by machining--various cutting processes involving the removal of metal. A widely used method of cutting spur-gear teeth is by means of a rotary cutter whose shape corresponds to the required tooth space (a so-called formed cutter). Mounted on a milling machine, the cutter takes successive cuts from the gear blank, which is rotated the correct distance after each cut to give the desired spacing of the teeth This precisely controlled step-by-step rotation of the blank is called "indexing" and is performed by an indexing device, or dividing head, which is part of the equipment of the milling machine. Similar gear-cutting operations can also be performed on a suitably equipped lathe. Helical gears can likewise be produced by the formed-cutter technique: the gear blank must be set at the correct angle to the cutter, and work table of the milling machine must be swiveled through the helix angle of the teeth being cut, so that the plane of the cutter becomes tangent to the helix.



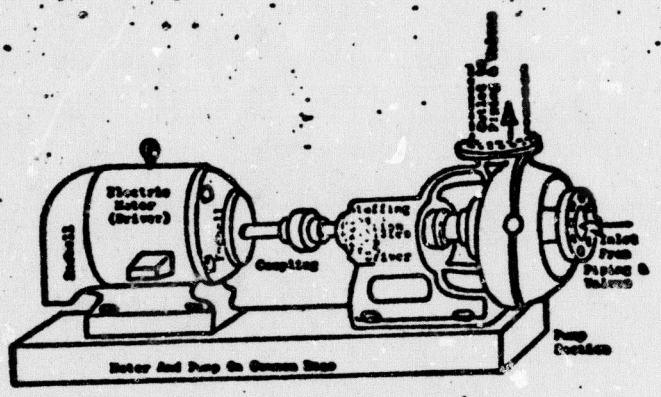
GEAR CUTTING WITH A FORMED CUTTER

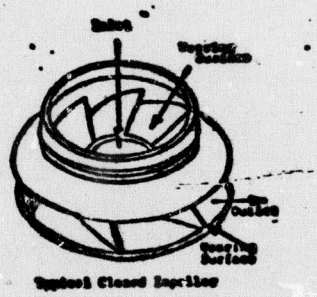
PUMP INFORMATION FOR WELDORS

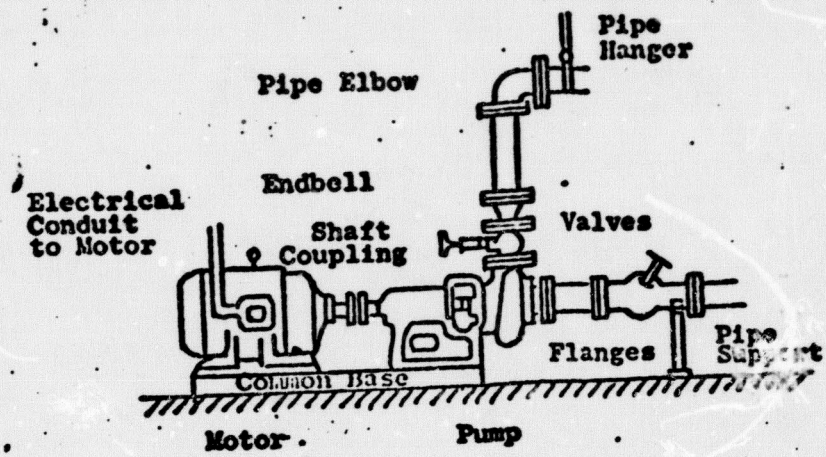
The most common form of pump used industrially is the centrifugal type. On these, liquids impinge on central area of the impellor and are flung off the blades by centrifugal force. Engineering design factors determine whether closed or open impellors will be used. Impellor blades are usually simple to repair or overlay with the Eutalloy Process.

Rotary pumps such as lobe types, Moyno "worms", screw type, and gear type pumps are common in process industries "pushing" viscous liquids with or without entrained solids. Piston pumps have parts similar to air compressors or internal combusion engines.. Vane pumps have sliding vanes whose outer edges wipe (and wear) as they scrape across the pumps internal housing surface.

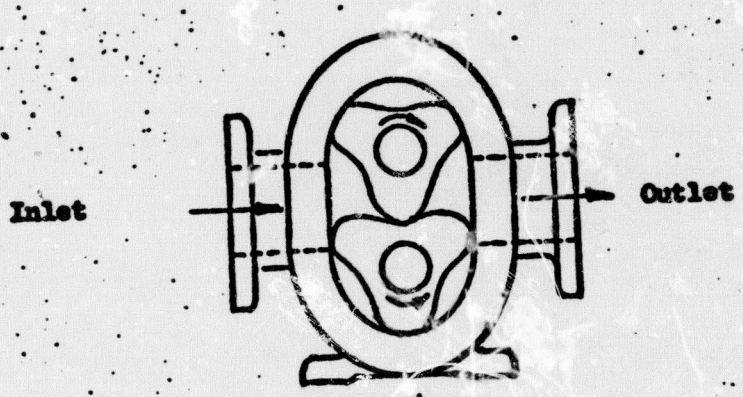
Internal moving parts, as well as pump housings are usually of cast iron with a liberal distribution of stainless and bronze versions -- as service conditions require. Modern pumps use alloy steel - heat treated shafts, except where corrosive conditions demand stainless steel.



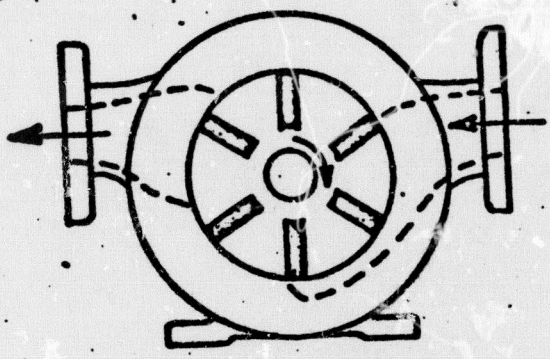




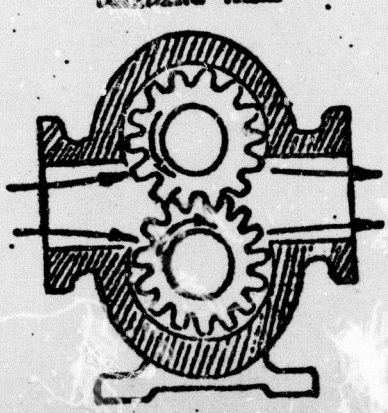
Shafts, Pumps, & Valves in one small space. In fact - if pumped liquids are very thick, a gear reducer gets inserted between motor and pump to reduce speed while increasing torque. Common applications like these are Golden Opportunities for XumerLIFE products.



LOBE



SLIDING VANE



GEAR TYPE

VALVE INFORMATION FOR WELDORS

The basic valve design upon which practical weld repairs are performed is the gate or sluice valve. These are frequently of tapered wedge design and move vertically into their seating surfaces.

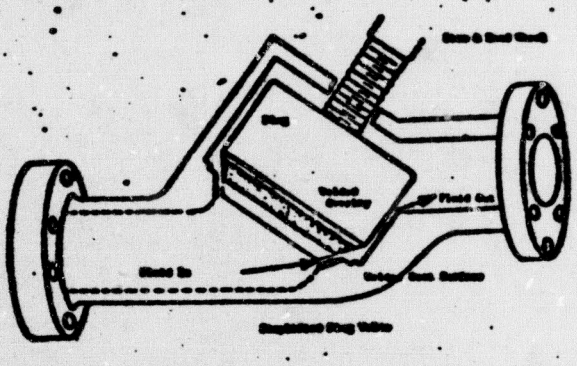
Variations include a hinged (at one end) flapper or check valve and a thin knife edged sliding gate within a close-fitting housing.

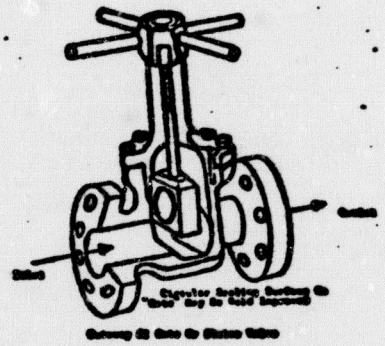
Globe or plug valves are similar to the valves that turn your home faucets on and off. Instead of washers, however, the wearing surface is frequently a temperature and/or corrosion resistant welded overlay. Exhause valves for internal combustion engines are similar in concept.

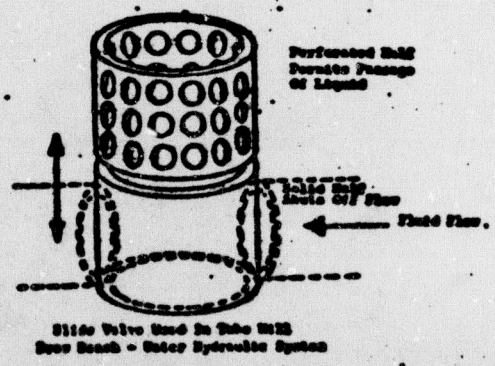
Butterfly valves are thin discs that pivot on a central axis to control the flow of gases or low pressure fluids.

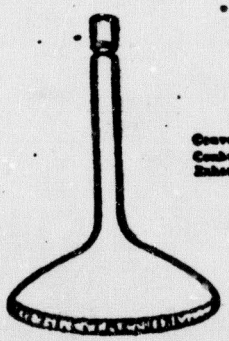
Many types of slide valves of cylindrical or rectangular shape will be encountered in the minerals processing or petrochemical industries.

Metals used in all the above are dependent on service conditions. Institute A/S's are trained to select a buildup alloy and process exceeding service needs and compatible with base metal.









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Selected Values of Thermodynamic Properties of Metals and Alloys

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Aluminum-Nickel

Part I. Discussion

Phase Diagram. Four intermediate phases are known. The phase boundaries are well established for $x_{Ni} < 0.50$, but there is dispute about the boundaries for $x_{Ni} > 0.50$ (Hansen, 1958). ϵ has the ordered orthorhombic ($D0_{20}$) Al_3Ni prototype structure; δ has the ordered trigonal ($D5_{13}$) Al_3Ni_2 prototype structure with numerous lattice vacancies; β' has an ordered bcc (B2) crystal structure isotypic with CsCl, however, for $x_{Ni} < 0.5$, the Ni deficiency is achieved by vacancies on Ni lattice sites rather than by substitution of Al; α' has an ordered fcc ($L1_2$) structure isotypic with $AuCu_3$. An Al_3Ni_5 bc tetragonal structure has also been reported (Pearson, 1958).

Solid Alloys. Selected values were taken mainly from calorimetric measurements of direct reaction of pressed metal powders by Kubaschewski (1958), 298°K, $x_{Ni} = 0.25$-0.80. For a discussion of the method and its probable accuracy, see Ni-Ti. Oelsen and Middel (1937), 293°K, $x_{Ni} = 0.19$-0.94, measured ΔH by pouring $Al_{(l)}$ and $Ni_{(l)}$ together into a calorimeter at room temperature. Their results are generally more exothermic than selected values by 400 - 2000 cal/g-atom. The more exothermic result is attributed by Kubaschewski to the presence of O and N impurities in the Ni which react with the Al. This method might involve very uncertain final states. Nevertheless, Oelsen and Middel's values were selected for α.

Part II. Tables

Al Atomic Weight = 26.9815

Ni Atomic Weight = 58.71

TABLE 1

Heats of Formation of Solid Alloys at 298.15°K

$$(1-x)Al_{(s)} + xNi_{(s)} = Al_{1-x}Ni_{x(s)}$$

x_{Ni}	Phase	ΔH	x_{Ni}	Phase	ΔH
0.25*	ε	- 9000	0.718*	α′	-10050
0.362*	δ	-12400	0.780*	α′	- 7500
0.406*	δ	-13850	0.902*	α	- 3800
0.45*	β′	-14070	0.950	α	- 1950
0.50	β′	-14050(±1000)			
0.588*	β′	-12260			

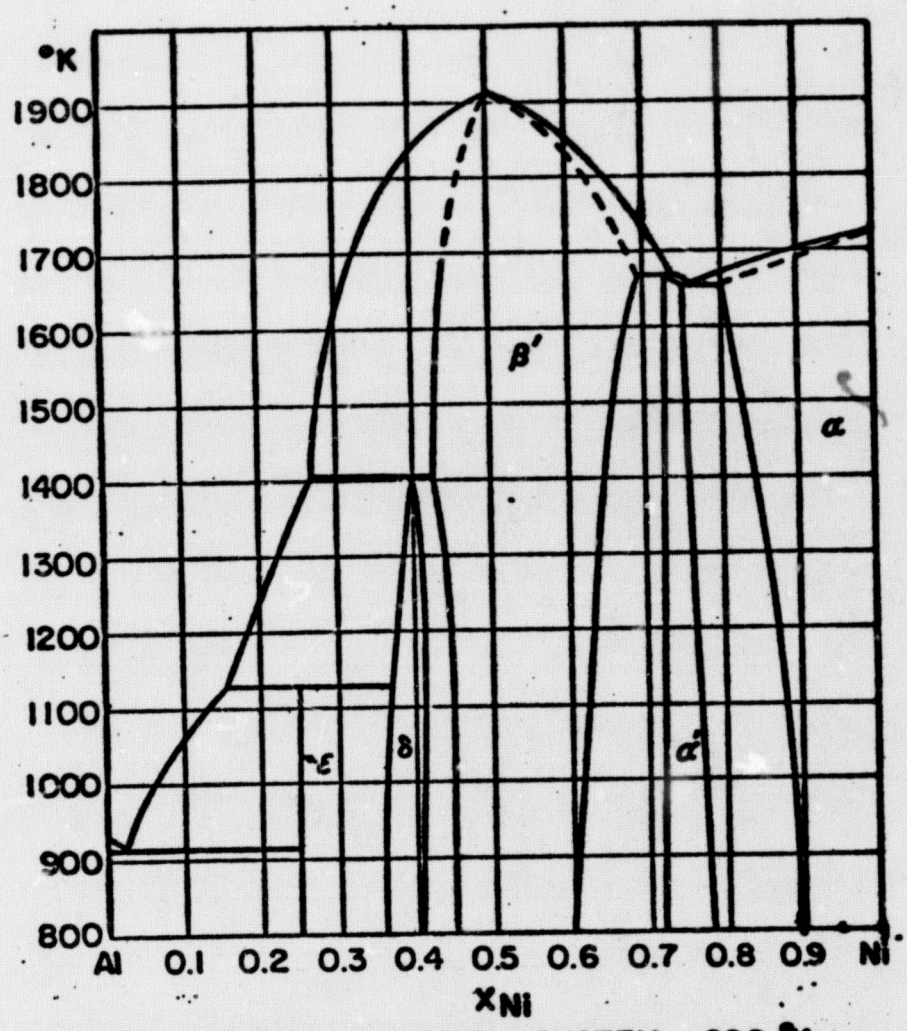
*Phase boundary

Part III. References

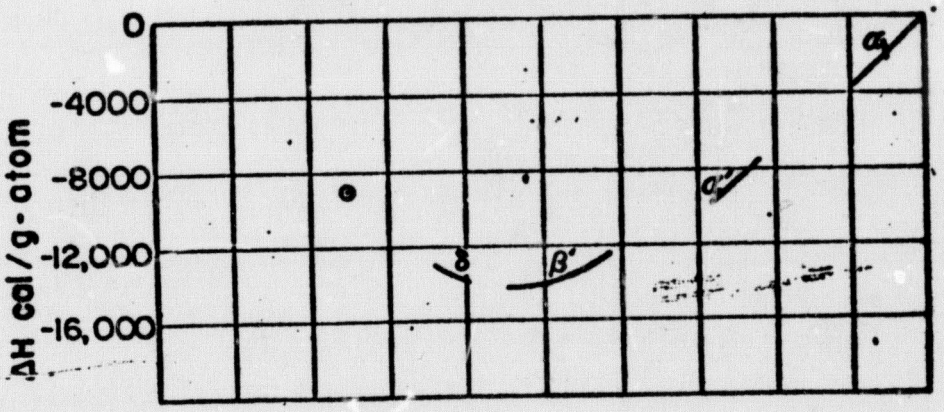
(For references not in list, see General References)

Kubaschewski, O., 1958, Trans. Faraday Soc., 54, 814-20. ΔH (298°K, x_{Ni} = 0.25 - 0.80).

Oelsen, W., and W. Middel, 1937, Mitt. Kaiser Wilhelm Inst. Eisenforsch., 19, 1-26. ΔH (293°K, x_{Ni} = 0.19 - 0.94).



ALUMINUM-NICKEL SYSTEM, 298 °K



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ENGINEERING SOCIETIES LIBRARY MAY 28 1937

Zur Thermochemie der Legierungen I.

Unmittelbare Bestimmung der Bildungswärmen der Legierungsreihen Kobalt-Silizium, Eisen-Aluminium, Kobalt-Aluminium, Nickel-Aluminium, Kupfer-Aluminium und Antimon-Zink für den Gußzustand*).

Von

Willy Oelsen und Walther Middel.

Einleitung. — Versuchsführung. — Die Kobalt-Silizium-Legierungen. — Vergleich mit den Eisen-Silizium- und Nickel-Silizium-Legierungen. — Die Eisen-Aluminium-Legierungen. — Die Kobalt-Aluminium-Legierungen. — Die Nickel-Aluminium-Legierungen. — Die Kupfer-Aluminium-Legierungen. — Die Antimon-Zink-Legierungen. — Zur Thermochemie der Zwischenlegierungen. — Zusammenfassung.

Durch die Röntgeninterferenzverfahren hat sich die Kenntnis der Struktur metallischer Phasen in den letzten Jahren über die Erkenntnisse aus der thermischen Analyse hinaus sehr gemehrt, so daß allmählich eine Uebersicht über die intermetallischen Reaktionsverhältnisse gewonnen werden kann. Bemerkenswert ist, daß gegenüber dem schnellen Anhäufen neuer Daten über den Kristallbau und die physikalischen Eigenschaften der metallischen Stoffe zur Thermochemie der Legierungen neben und nach den grundlegenden Arbeiten von W. Biltz und seinen Mitarbeitern[1]) nur wenige Beiträge im Schrifttum erschienen sind. Die Kenntnis der Bildungswärmen der intermetallischen Phasen ist aber für eine systematische Chemie der Legierungen unerläßlich. Wenn von einer legierungbildenden Affinität der Metalle gesprochen wird[2]), sollten sie nicht völlig außer acht gelassen werden[3]).

Von besonderer Bedeutung ist die Kenntnis der Bildungswärmen der Legierungen weiterhin für eine Beurteilung ihres chemischen Verhaltens, sei es im festen oder auch im flüssigen Zustand für elektrochemische oder metallurgische Fragen.

Daß nur für so wenige der intermetallischen Phasen die Bildungswärmen bekannt sind, beruht darauf, daß für ihre Bestimmung bisher fast ausschließlich die für thermochemische Messungen üblichen mittelbaren Verfahren des Auflösens oder des Verbrennens angewendet wurden. Diese versagen aber bei vielen Legierungen, während sie bei den anderen ein sehr genaues Arbeiten und eine große experimentelle Geschicklichkeit voraussetzen. Die Bildungswärmen der Legierungen machen meist nur einen äußerst kleinen Bruchteil ihrer Lösungswärmen und einen noch viel kleineren ihrer Verbrennungswärmen aus. Voraussetzung für die Anwendung der mittelbaren Verfahren ist ferner das Vorliegen einer wohldefinierten homogenen Kristallart, da es einmal die geringen Substanzmengen nicht zulassen, eine gute Durchschnittsprobe zu nehmen, und anderseits geringe Unterschiede der Zusammensetzung schon sehr erhebliche Abweichungen bedingen können, wenn eines der Metalle eine wesentlich höhere Lösungswärme aufweist als das andere. Außerdem bedingt die Herstellung der Legierungen, besonders der hochschmelzenden, stets eine Aufnahme von Fremdelementen, die zwar die wahre Bildungswärme nicht wesentlich verändern, aber doch die um ein Vielfaches höheren Lösungswärmen merklich beeinflussen und damit erhebliche Fehler der aus den Lösungswärmen als Differenz zu berechnenden Zahlenwerte der Bildungswärme hervorrufen können. Das bei Lösungsversuchen meist notwendige Pulvern der Proben birgt immer die Gefahr einer Oxydation, die z. B. an verschiedener Auflösungsgeschwindigkeit frisch gepulverter und älterer Proben erkannt werden kann und sicher nicht ohne Einfluß auf das Ergebnis ist. Besondere Schwierigkeiten ergeben sich auch bei der Bewertung der Vorgänge im Lösungsmittel; so können die Reaktionsprodukte beim Lösen der reinen Metalle oder ihrer Gemenge andere sein als diejenigen beim Lösen ihrer Legierungen im gleichen Lösungsmittel[4]).

Die Legierungen zählen nun aber zu den wenigen Stoffen, deren Bildung aus den Elementen äußerst leicht erfolgt genügt doch in den meisten Fällen ein einfaches Zusammenschmelzen. Damit ist schon die Möglichkeit gegeben, auch ihre Bildungswärme unmittelbar zu bestimmen. Die Vereinigung der beiden Metalle braucht nur in einem Kalorimeter von Raumtemperatur etwa durch Zusammengießen bewirkt zu werden. Die Fehlermöglichkeiten bei einem auf diesem Grundgedanken entwickelten Verfahren sind wesentlich geringer als bei den üblichen mittelbaren Verfahren. Einmal werden neben der Reaktionswärme nur die Wärmeinhalte der Metalle mitgemessen; diese machen aber nur

*) Doktor-Dissertation (W. Middel), genehmigt von der Philosophisch-Naturwissenschaftlichen Fakultät der Universität Münster. — Ueber die Ergebnisse dieser Arbeit wurde auszugsweise berichtet von F. Korber (Stahl u. Eisen 56 (1936) S. 1401/11 [Stahlw. Ausch. 329], Vortrag vor der Hauptversammlung des Vereins deutscher Eisenhüttenleute am 29. Nov. 1936).

[1]) a) W. Biltz und G. Hohorst: Z. anorg. allg. Chem. 121 (1922) S. 1/21; b) W. Biltz und C. Hase, ebenda 129 (1923) S. 141/60; c) W. Biltz und W. Wagner, ebenda 131 (1924) S. 1/12; d) W. Biltz und H. Pieper, ebenda 131 (1924) S. 13/23; e) W. Biltz, W. Wagner, H. Pieper, W. Holverscheidt, ebenda 134 (1924) S. 25/36; f) W. Biltz, ebenda 131 (1924) S. 37/43, zusammenfassender Bericht; g) W. Biltz und W. Holverscheidt, ebenda 140 (1924) S. 261/76; h) W. Biltz: Z. angew. Chem. 37 (1924) S. 391/92, zusammenfassender Vortrag; i) W. Biltz, F. Meyer, C. Neuerkoweit: Z. anorg. allg. Chem. 176 (1928) S. 23/45; k) W. Biltz, G. Rohlfs, H. C. von Vogel, ebenda 220 (1934) S. 113/41; l) W. Biltz: Z. angew. Chem. 48 (1935) S. 729/31; m) W. Biltz: Forschungen und Fortschritte 11 (1935) S. [illegible].

[2]) Siehe z. B. P. Oehlinger: Naturwiss. 24 (1936) S. 391/95; Metallwirtsch. 14 (1935) S. 115/19.

[3]) Siehe auch schon W. Biltz und F. Meyer: l c), dort S. 24.

[4]) Vgl. W. Biltz und F. Meyer: Z. anorg. allg. Chem. 176 (1928) S. 23/45, Anhang über die Auswertung der Messungen von W. Holverscheidt l b an Zinklegierungen.

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einen Bruchteil ihrer Lösungswärmen aus und sind oft von der gleichen Größenordnung wie die Reaktionswärmen. Sodann wirken sich kleine Beimengungen der Ausgangsstoffe meist nur entsprechend ihrem Gehalt auf die Meßergebnisse der Bildungswärme aus, während sie die Wärmeinhalte kaum verändern. Weiterhin ergibt sich die Bildungswärme für die Gesamtmenge der Legierung alle jene Fehler durch die Probenahme fallen heraus.

Als besonderer Vorteil hat aber zu gelten, daß ohne grundsätzliche Schwierigkeiten und in verhältnismäßig kurzer Zeit eine ganze Legierungsreihe untersucht werden kann, wobei ein Wert durch die anderen nachgeprüft und gesichert wird, und anderseits die Zusammensetzungen der wichtigsten Phasen des betreffenden Systems sich ohne weiteres aus dem Gang der Bildungswärmen mit der Konzentration ergeben und nicht erst aus den Zustandsschaubildern entnommen werden müssen. Die Bildungswärmen können damit auch als ein weiteres Hilfsmittel zur Auffindung dieser Phasen dienen.

F. Körber und W. Oelsen[1]) haben bereits an dem Beispiel der Eisen-Silizium-Legierungen gezeigt, daß man deren Bildungswärmen durch Zugießen von flüssigem Eisen zu festem Silizium (bzw. von flüssigem Silizium zu festem Eisen) leicht in erster Annäherung unmittelbar bestimmen kann. In Anlehnung an diese Versuche haben sodann W. Oelsen und H. O. von Samson-Himmelstjerna[2]) die Zahlenwerte der Bildungswärmen der Nickel-Silizium-Legierungen festgestellt[3]). Die vorliegende Arbeit hat als Fortsetzung und auch als Nachprüfung jener ersten Untersuchungen und ihrer Ergebnisse zu gelten. Es wurden nach dem grundsätzlich gleichen Verfahren die Bildungswärmen der Kobalt-Silizium-Legierungen und -Schmelzen, diejenigen der Legierungen des Aluminiums mit Eisen, Kobalt, Nickel und Kupfer sowie diejenigen der Antimon-Zink-Legierungen ermittelt, in jedem Fall für den ganzen Konzentrationsbereich. Die Ergebnisse werden mit den wenigen Zahlenwerten des Schrifttums verglichen und in Beziehung zu den vorliegenden Zustandsschaubildern der Legierungen gebracht.

Besondere Aufmerksamkeit sollte auch den Bildungswärmen der Mischkristallreihen geschenkt werden, die z. B. in den angeführten Zweistoffsystemen des Aluminiums über weite Bereiche auftreten. Es war festzustellen, ob die Bildungswärmen von Mischkristallreihen sich grundsätzlich von denjenigen heterogener Gemenge unterscheiden, und damit nachzuprüfen, ob das nach den bisherigen Erfahrungen getroffene Feststellungsmerkmal, nicht von Mischkristallen oder Lösungen zwischen einem Metall und einer Metallverbindung zu sprechen[4]), begründet ist.

Mit Hilfe der Wärmeinhalte der Schmelzen werden für die Systeme Kobalt-Silizium, Kupfer-Aluminium und Antimon-Zink auch die Mischungswärmen für den flüssigen Zustand angegeben.

I. Die Versuchsführung.

Ueber das Grundsätzliche der Versuchsführung wurde bereits von F. Körber und W. Oelsen[1]) berichtet. Da sich die Arbeitsweise und die einfachen Geräte bei den weiteren Versuchen bewährt haben, seien sie hier nur kurz beschrieben. Als wesentlichste Hilfsmittel sind die Schmelzeinrichtungen anzusehen. Für Temperaturen bis 1000° standen zwei kleine Widerstandsöfen zur Verfügung, für höhere Temperaturen zwei Kurzschlußöfen nach Tammann, die ein schnelles Schmelzen und gutes Regeln der Temperatur gestatten. Als Schmelztiegel für Aluminium (800 bis 1000°), Zink (650 bis 745°), Antimon (bis 715°) und Kupfer (bis 1300°) dienten Graphittiegel, die eine Oxydation der Schmelzen wenn nicht völlig verhindern, so doch erheblich hemmen. Mit einer nennenswerten Aufkohlung der genannten Metalle ist in den angegebenen Temperaturbereichen nicht zu rechnen. Eisen, Kobalt, Nickel und Silizium wurden unter einer Kalksilikatschlacke oder auch unter einer Sanddecke in Sandtiegeln niedergeschmolzen. Bei Temperaturen bis 1100° wurde die Temperaturmessung mit Thermoelementen, bei höheren Temperaturen mit einem Glühfadenpyrometer durchgeführt.

Die Reaktionserfolgte in einem einfachen Reaktionsgefäß, dessen Aufbau und Maße aus Abb. 1 hervorgehen. Das dickwandige Eisengefäß nimmt einen bei 1000° vorgeglühten Tiegel aus Kieselsand auf. Der Zwischenraum zwischen Eisengefäß und Tiegel wird mit trockenem Sand aufgefüllt, der dem Tiegel Halt gibt und zum weiteren Wärmeschutz gegen die Gefäßwand dient. Der Sandtiegel kann durch einen Deckel aus gebranntem Material geschlossen werden, so daß das Gefäß mit der Metallschmelze geschüttelt und auch völlig umgekehrt werden kann, um ein gutes Durchmischen zu erzielen. Der Sandtiegel kann auch durch einen Trichter ersetzt werden, was bei Versuchen mit niedrigen Metallpunkten zweckmäßig ist, die beim Zusammengießen zum Spritzen neigen (Nickel-Aluminium). Das Gefäß wird durch einen übergreifenden Deckel verschlossen, so daß es in Wasser gebracht werden kann, ohne daß dieses in das Innere gelangt. Das Reaktionsgefäß wird mit Hilfe des Deckelbügels in ein Wasserkalorimeter von 6,3 l Inhalt gehängt. Der Gesamtwasserwert (einschließlich der Wasserwerte für das in Abb. 1 gezeigte Gefäß, den Rührer und die Thermometer) betrug 7,0 bis 7,6 kcal.

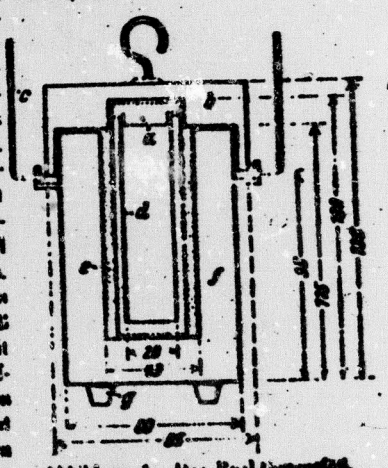

Abbildung 1. Das Reaktionsgefäß.
a = Tiegel bei 1000° ausgeglüht.
b = Eisengefäß.
c = Deckel zum Aufsetzen des Gefäßes.
d = Vorgeglühter Kieselsandtiegel.
e = Sandfüllung.
f = Schamotteboden.
g = Kegelstumpf.

Bei gleichbleibender Rührergeschwindigkeit wird der Temperaturgang des Kalorimeters in der Vorperiode verfolgt. Nach Einlassen werden die Metalle in den Ofen

[1]) F. Körber und W. Oelsen: Mitt. Kais.-Wilh.-Inst. Eisenforsch., Düsseldorf, 18 (1936) S. 109/30; s. a. Naturwiss. 22 (1934) S. 285/88; F. Körber: Stahl u. Eisen 56 (1936) S. 133/40; W. Oelsen: Stahl u. Eisen 57 (1937) S. 1049/53; F. Körber: Stahl u. Eisen 58 (1938) S. 1105/19.

[2]) W. Oelsen und H. O. von Samson-Himmelstjerna: Mitt. Kais.-Wilh.-Inst. Eisenforsch., Düsseldorf, 19 (1937) S. 131/33.

[3]) Nach Abschluß der vorliegenden Arbeit teilte H. O. von Samson-Himmelstjerna [Z. Metallkde. 29 (1937) S. 197/202] die Ergebnisse weiterer Versuche mit, die nach dem gleichen Verfahren durchgeführt und nach den gleichen einfachen Ueberlegungen ausgewertet wurden. Untersucht wurden die Systeme Pb-Bi, Sn-Bi, Pb-Sn, Pb-Cd, Pb-Ag, Pb-Sn-Bi, Cd-Zn, Ag-Zn, Cu-Ni und Fe-Ni.

[4]) Siehe die Ausführungen von G. Tammann: Grundlagen der metallischen Mischkristalle. Handbuch der Metallphysik, herausgegeben von G. Masing (Leipzig 1936). Anderweitige Vorbehalte s. a. H. [illegible]

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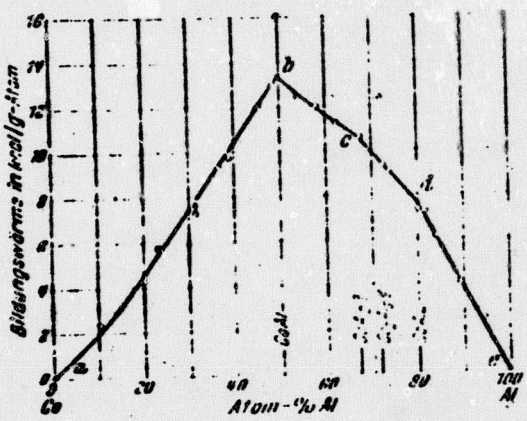

Abbildung 16. Die Bildungswärmen der Kobalt-Aluminium-Legierungen bei Raumtemperatur je Gramm-Atom. (Zahlentafel 5.)
⊙ Werte nach W. Fitz und W. Hofer-Leon.

W. Oelsen und H. Lichtenberg wurde diese Durchbiegung bestätigt; es ergab sich bei 13 Atom-% Al ein deutlich ausgeprägter Knick, der der Grenze des β-Gebietes in Abb. 17 entspricht[20]).

Die Bestimmung der Mischungswärmen der Kobalt-Aluminium-Schmelzen wurde nicht durchgeführt, da die Ermittlung der Wärmeinhalte der Schmelzen durch die schlechte Vergießbarkeit der in kleinen Tiegeln geschmolzenen Mischungen sehr erschwert ist. Aus der großen Steigerung der Temperatur der Mischung beim Zusammengießen von Aluminium und Kobalt folgt aber unmittelbar, daß die Mischungswärmen der Schmelzen nur unerheblich geringer sein können als die Bildungswärmen der Legierungen.

V. Die Bildungswärmen der Nickel-Aluminium-Legierungen.

Außer der mehr qualitativen Aussage von A. v. Gwyer[21]), daß die Reaktion beim gemeinsamen Erhitzen von Nickel und Aluminium heftiger und unter stärkerer Temperaturerhöhung erfolgt als beim Erhitzen von Kobalt und Aluminium, die bestätigt werden wird, liegen Zahlenwerte im Schrifttum nicht vor.

Verwendet wurde ein Würfelnickel (99,0% Ni, 0,3% Fe, < 0,5% Co und etwa 0,2% C vor dem Umschmelzen). Nach dem Umschmelzen sank der Kohlenstoffgehalt unter 0,02% ab, ebenso verschlackte ein Teil des Eisens und des Kobalts. Als Aluminium wurde wieder das bereits in den vorigen Abschnitten gekennzeichnete Hüttenaluminium verwandt. Das ungeschmolzene Nickel wurde durch eine Glasschlacke und durch Zusatz von 0,5% Mn vor dem Abguß sorgfältig desoxydiert. Eine solche Desoxydation ist unbedingt erforderlich, da das Nickel aus seinen Silikaten bei 1000° bis zu 4,5% NiO zu lösen vermag[21]). Ein hoher Oxydgehalt des Nickels würde die Bildungswärmen gerade der Nickel-Aluminium-Legierungen erheblich falschen können, da die Umsetzung

$$3\,NiO + 2\,Al = 3\,Ni + Al_2O_3$$

die sehr hohe Wärmetönung von 206 kcal entsprechend der Differenz der Bildungswärmen der Tonerde und des Nickeloxyduls liefert. Diese zusätzliche Wärmetönung bei oxydhaltigen Nickelschmelzen müßte besonders deutlich bei den ersten kleinen Aluminiumzugaben in Erscheinung treten. Bei den Versuchen dieser Arbeit wurden entsprechende Beobachtungen nicht gemacht; die Desoxydation der Nickelschmelzen durch die Kalksilikatschlacke und den Mangenzusatz war offenbar hinreichend.

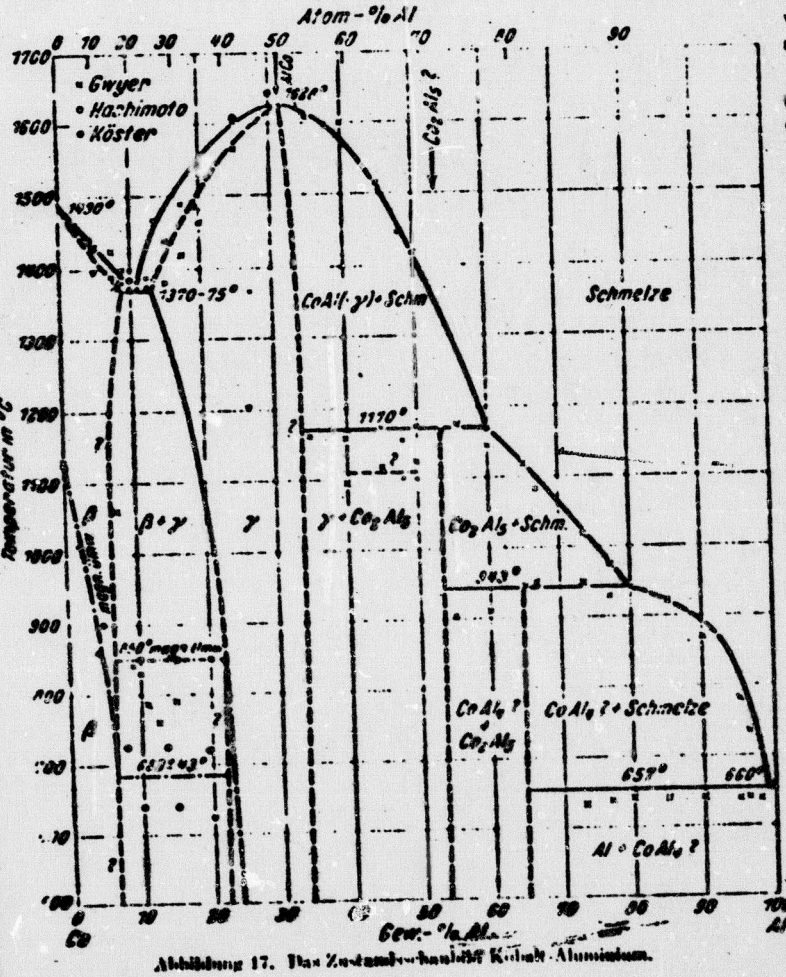

Abbildung 17. Das Zustandsschaubild Kobalt-Aluminium.

Die Phasengrenzen des Zustandsschaubildes im Bereich zwischen 14 und 40 Atom-% Al treten auf der Teilstrecke a b des Bildungswärmen-Konzentrationszuges nicht deutlich in Erscheinung. Die Teilstrecke a b ist aber nach unten durchgebogen. Bei eingehender Nachprüfung der Bildungswärmen der Legierungen mit 9 bis 50 Atom-% Al durch

[20]) Vgl. F. Körber: Mitt. a. d. Kais.-Wilh.-Inst. für Eisenforschung, Düsseldorf, 18 (1936) S. 109/111; die ausführliche Arbeit erscheint demnächst in den Mitteilungen des Kais.-Wilh.-Inst. für Eisenforschung, Düsseldorf.

[21]) Siehe z. B. P. Bardenheuer und R. Brauns: Mitt. Kais.-Wilh.-Inst. Eisenforsch., Düsseldorf, 17 (1935) S. 127/32, sowie W. Oelsen und H. Kremer: Mitt. Kais.-Wilh.-Inst. Eisenforsch., Düsseldorf, 18 (1936) S. 89/100.

Zahlentafel 6.

Die Bildungswärme der Nickel-Aluminium-Legierungen.

No.	Ni-Einwage in mg	Temperatur-erhöhung des Ni-Kalorim. in °C	Al-Einwage in mg	Temperatur-erhöhung des Al-Kalorim. in °C	n_{Ni} in %	n_{Al} in %	$\Delta\vartheta_{Ni}$ in °C	$\Delta\vartheta_{Al}$ in °C	$\Delta\vartheta_{Ni}$ in %	$\frac{\Delta\vartheta_{Al}}{\Delta\vartheta_{Ni}}$	q in cal/g	Bemerkungen
61	68,5	16000					2,623	$\Delta\vartheta_{Ni}$ 9%	0,0383°, g oder			
								$\Delta\vartheta_{Al}$	288 cal/g für 1600° (20°)			
62	80,0	16000					1,540	$\Delta\vartheta_{Ni}$ 9%	0,0385°, g oder			
									289 cal/g für 1600° (20°)			
59	70,7	16000	2,0	871	1,278	5,8	3,16	2,89	0,24	2,7	2,1	Sandtiegel.
52	69,0	16000	4,0	855	1,321	11,2	3,58	2,85	0,73	5,5	4,1	+ 1,0 g Ni haben nicht reagiert; Sandtiegel.
56	66,9	16000	5,6	850	1,318	15,4	3,88	2,87	1,01	7,6	5,7	+ 1,75 g Ni haben nicht reagiert; Sandtiegel.
53	69,0	16000	8,1	859	1,176	20,3	4,58	2,99	1,59	12,0	8,1	+ 2,1 g Ni haben nicht reagiert; Sandtiegel.
58	68,6	16000	9,7	858	1,329	23,5	5,00	3,05	1,85	13,9	8,7	+ 0,7 g Ni haben nicht reagiert; Sandtiegel.
62	69,3	16000	10,8	853	1,367	24,7	5,15	3,15	2,00	15,0	9,6	+ 0,9 g Ni, + 0,6 g Al haben nicht reagiert; Sandtiegel.
51	67,3	16000	10,35	851	1,199	32,2	4,23	2,35	1,88	14,1	11,9	+ 2,4 g Ni, + 0,25 g Al haben nicht reagiert; Sandtiegel.
55	44,3	16000	12,0	8560	1,201	37,0	4,25	2,20	2,05	15,4	12,8	+ 0,1 g Ni haben nicht reagiert; Sandtiegel.
56	24,6	16000	9,1	8,57	0,767	45,4	2,98	1,33	1,65	12,3	16,1	Sandtiegel.
41	25,1	16000	9,8	855	0,791	45,9	3,16	1,38	1,78	13,4	16,9	+ 0,15 g Ni haben nicht reagiert; Sandtiegel.
198a	18,5	16000	20,0	850	1,569	47,4	6,06	2,73	3,35	25,2	16,1	+ 1,4 g Ni haben nicht reagiert; Sandtiegel.
200	18,0	16000	19,8	849	1,552	47,2	5,88	2,69	3,19	24,0	15,4	+ 1,1 g Ni haben nicht reagiert; Tiegel mit 80% Al_2O_3.
201	18,3	16000	20,0	850	1,569	47,3	5,95	2,71	3,20	24,0	15,3	+ 0,9 g Ni haben nicht reagiert; Tiegel mit 80 % Al_2O_3.
202	16,4	16000	21,5	857	1,548	50,2	6,06	2,67	3,39	25,5	16,6	Sandtiegel.
199	17,7	16000	23,8	849	1,578	50,2	7,83	3,34	4,49	33,7	17,0	+ 1,4 g Ni haben nicht reagiert; Tiegel mit 80 % Al_2O_3.
45	23,2	16000	14,5	855	0,933	57,6	3,81	1,52	1,89	14,2	13,2	+ 0,1 g Ni haben nicht reagiert; Sandtiegel.
60	22,3	16000	17,5	849	1,028	63,1	3,56	1,69	1,85	13,9	13,5	+ 2,05 g Ni haben nicht reagiert; Sandtiegel.
46	21,25	16000	23,0	855	1,206	67,3	3,83	1,87	1,98	14,8	14,7	+ 0,1 g Ni haben nicht reagiert; Sandtiegel.
47	24,4	16000	33,2	859	1,617	74,9	4,33	2,32	2,01	15,1	9,2	+ 0,55 g Ni haben nicht reagiert; Sandtiegel.
48	21,6	16000	38,2	853	1,832	77,2	4,56	2,52	2,04	15,3	8,6	+ 0,35 g Ni haben nicht reagiert; Sandtiegel.
99	19,7	16000	38,2	8560	1,732	80,8	4,02	2,34	1,68	12,6	7,2	+ 0,1 g Ni haben nicht reagiert; Sandtiegel.
50	11,6	16000	38,3	8,59	1,668	83,1	3,39	2,15	1,24	9,3	5,6	Sandtiegel.
54	10,0	16000	38,2	855	1,5836	89,3	2,78	1,96	0,82	6,2	3,9	Sandtiegel.
57	2,6	16000	38,1	855	1,4548	97,0	1,88	1,66	0,22	1,6	1,1	Sandtiegel.

[1]) Mit Glühfadenpyrometer gemessen (Fehler ± 10°). — [2]) Thermoelektrisch gemessen. — [3]) $n_{Ni} = \frac{m_{Ni}}{53,69}$; $n_{Al} = \frac{m_{Al}}{26,99}$. — [4]) $\Delta\vartheta$ ist die Gesamttemperaturerhöhung des Kalorimeters, Anfangstemperatur 20 bis 20,5°. — [5]) $\Delta\vartheta'$ ist die Temperaturdifferenz durch die Wärmeeinheit von Nickel und Aluminium: $\Delta\vartheta' = m_{Ni} \cdot \Delta\vartheta'_{Ni} + m_{Al} \cdot \Delta\vartheta'_{Al}$. — [6]) Wasserwert: 7,58 ± 0,03 kcal/°.

Schon ohne eine Messung war zu bemerken, daß die Reaktion beim Zusammenlegen von Nickel (1440°) zu flüssigem Aluminium (850°) eine viel höhere Temperatur des Gemisches liefert als die beim Zugießen von Kobalt. Das Gemisch leuchtet grell-weiß auf, selbst durch eine ziemlich dicke Schmelzhülle gesehen. Bei äquivalenten Mengen Aluminium und Nickel dürften Temperaturen von annähernd 2000° erreicht werden trotz der erheblichen Wärmeableitung durch den zuvor kalten Tiegel. In der Reaktionszone wurde der Tiegel sicher auf über 1450° erhitzt, da beim Schmelzen glasartig geschmolzene Massen und innen auch Anzeichen für ein Aufschmelzen erkennen ließ. Die kurze Dauer der Temperaturerhöhung erlaubte schon aus, was durch das Aluminium bis zu 2% Si aus den Tiegeln zu reduzieren, jedoch nur bei den Schmelzen mit etwa 50 Atom-% Al, bei denen die höchsten Endtemperaturen erreicht wurden. Ein Teil der Versuche für etwa 50 Atom-% Al wurde daher mit hochtonerdehaltigen Tiegeln (> 80% Al_2O_3) in Reaktionsgefäß wiederholt. Die Siliziumgehalte blieben unter 0,5%, die Reaktionswärme war aber nicht genauer bestimmt als bei der Verwendung von Sandtiegeln. Die Siliziumgehalte der Legierungen wurden bei der Berechnung der Bildungswärmen außer acht gelassen.

In Zahlentafel 6 sind die Versuchsreihen, bei denen mit allen für die Berechnung notwendigen Einzelheiten gearbeitet wurde, nach steigenden Aluminiumgehalten der Legierungen geordnet. Die Wärmeinhaltswerte des Aluminiums sind wieder der Zahlentafel 4 bzw. der Abb. 17 zu entnehmen

Für den Wärmeinhalt des desoxydierten Nickels ergibt sich aus den Versuchen 61 und 62 der Wert von 6288 ± 11 cal/g für 1600° (20°), der allerdings um etwa 2% höher liegt als die Angaben des Schrifttums[12]) mit im Mittel 283 cal/g. Den Ausrechnungen wurde selbstverständlich der unter den gleichen Versuchsbedingungen ermittelte eigene Wert zugrunde gelegt.

Aus dem Vergleich der Spalten 9 und 10 der Zahlentafel 6 folgt unmittelbar, wie groß die Reaktionswärme im Vergleich zu der durch das flüssige Aluminium und das flüssige Nickel als Wärmeinhalt eingebrachten Wärmemenge ist. Schon bei 5,8 Atom-% Al (Versuch Nr. 59) beträgt die Reaktionswärme mehr als 12% der Summe der Wärmeinhalte, bei 45,9 Atom-% Al beträgt die Reaktionswärme bereits 130% der eingebrachten Wärmeinhalte.

In Abb. 18 sind die Bildungswärmen der Nickel-Aluminium-Legierungen je Gramm-Atom in Abhängigkeit vom Aluminiumgehalt (in Atom-%) aufgezeichnet. Durch die Versuchspunkte läßt sich der Linienzug a b c d e legen, der im Punkt c bei 50 Atom-% Al eine scharfe Spitze und in den Punkten b (bei etwa 25 Atom-% Al), d (bei etwa 67 Atom-% Al) nur schwach ausgeprägte Knicke aufweist. Weitere ausgezeichnete Konzentrationen sind nicht mit Sicherheit aus den Versuchspunkten herzuleiten. Die Beziehungen zwischen Bildungswärme und Konzentration sind also ähnlich denjenigen im System Co-Al (Abb. 16), aber wesentlich verschieden von denen im System Fe-Al (Abb. 14). Der Linienzug a b c d e ist nahezu symmetrisch zu der Senkrechten bei 50 Atom-% Al, die aluminiumreichen Legierungen haben eine nur wenig höhere Bildungswärme (je Gramm-Atom Ni) als die nickelreichen (je Gramm-Atom Al). Die Bildungswärme der Nickel-Aluminium-Legierung mit 50 Atom-% übertrifft die entsprechende im System Co-Al um etwa 4 kcal je Gramm-Atom Legierung, die entsprechende im System Fe-Al sogar um etwa 11 kcal je Gramm-Atom.

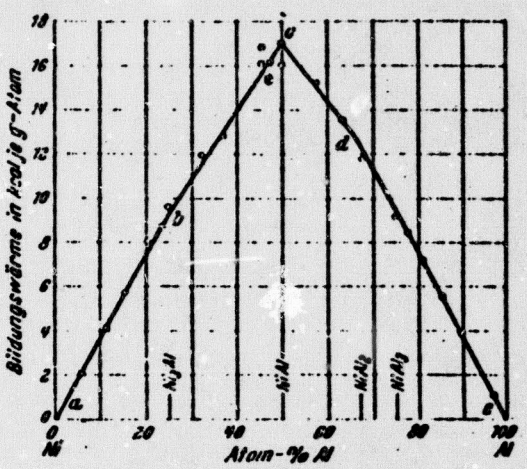

Abbildung 18. Die Bildungswärmen der Nickel-Aluminium-Legierungen bei Raumtemperatur je Gramm-Atom. (Zahlentafel 6.)

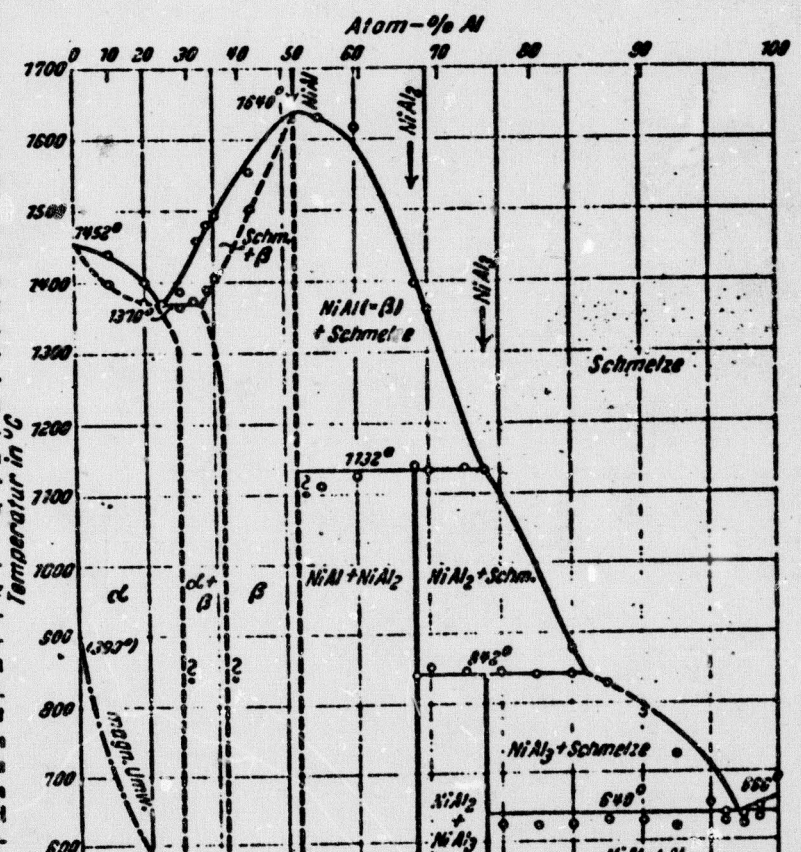

Abbildung 19. Das Zustandsschaubild Nickel-Aluminium.

Die Bildungswärme-Konzentrationsbeziehung der Abb. 18 entspricht völlig den Aussagen des Zustandsschaubildes[22]) Ni-Al (Abb. 19) über die Konzentrationen und auch über die Stabilität der verschiedenen auftretenden Phasen. Die Verbindung NiAl ist ausgezeichnet durch ein besonders hohes Maximum ihrer Schmelzkurve, das sich um etwa 140° über den Schmelzpunkt des reinen Nickels erhebt. [Im Zustandsschaubild Co-Al (Abb. 17) beträgt diese Ueberhöhung nur 140°; im Zustandsschaubild Fe-Al (Abb. 15) setzt die Erstarrung bei 50 Atom-% Al erst bei 1240°, also 200° unter dem Schmelzpunkt des Eisens ein.] Demgegenüber schmelzen die Verbindungen $NiAl_3$ (bei 1132°) und $NiAl_2$ (893°) bei viel tieferer Temperatur unter Zersetzung. Es ist daher verständlich, daß diese Verbindungen gegenüber der Verbindung NiAl auf dem Abschnitt c d e des Bildungswärme-Konzentrationslinienzuges nicht so ausgeprägt in Erscheinung treten.

Der Knickpunkt b bei etwa 25 Atom-% Al liegt nahe dem von A. G. C. Gwyer bei 1370° gefundenen eutektischen Punkt der α- und β-Mischkristalle; auch geht aus

[22]) Entnommen aus M. Hansen: Der Aufbau der Zweistofflegierungen (Berlin: Julius Springer 1936) S. 137 ff.

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Zahlentafel 7.

Die Bildungswärmen der Kupfer-Aluminium-Legierungen.

1 Nr.	2 Kupfer in mg	3 Temperatur des Kupfers °C	4 Aluminium in mg	5 Temperatur des Aluminiums °C	6 $n = \frac{n_{Cu}}{n_{Al}}$	7 Atom-% Al Atom-anteil	8 $\Delta\vartheta'$ °C	9 $\Delta\vartheta'_{Al}$ °C	10 $\Delta\vartheta - \Delta\vartheta'$ °C	11 $\frac{K}{m}(\Delta\vartheta - \Delta\vartheta')_{korr}$ kcal	12 $Q = \frac{K}{n}$ kcal
92	199.6	1255					2.375	$\Delta\vartheta'_{Cu}$ = 0,0238°/g oder A_{Cu} = 179 cal/g für 1255° (20°)			
104	149.9	1255					3.600	$\Delta\vartheta'_{Al}$ = 0,0240°/g oder A_{Al} = 180 cal/g für 1255° (20°)			
101	159.7	1255	[illegible]	850	2.72	8.0	1.51	4.02	0.52	3.9	1.4
100	149.8	1255	[illegible]	849	2.72	13.6	4.800	2.97	0.83	6.2	2.3
102	149.8	1255	10.0	850	2.90	19.2	5.80	4.18	1.21	9.1	3.1
93	98.8	1255	14.9	865	2.10	26.2	4.21	3.00	1.21	9.1	4.3
107	148.7	1255	32.55	850	3.54	31.0	7.35	4.87	2.48	18.6	5.25
103	149.05	1255	33.8	865	3.59	34.8	7.16	4.94	2.52	18.9	5.3
99*)	92.4	1255	24.6	852	2.36	38.4	4.98	3.39	1.59	11.9	5.1
108	134.2	1255	36.8	855	3.47	39.2	7.05	4.71	2.34	17.6	5.1
109	118.5	1253	37.0	848	3.23	42.1	6.50	4.35	2.15	16.2	5.0
91	59.2	1255	24.5	850	1.84	49.3	3.65	2.46	1.19	9.0	4.9
106	117.8	1255	96.7	830	3.52	69.2	6.79	4.60	2.19	16.4	4.7
98	53.1	1255	31.2	845	1.99	58.1	3.63	2.53	1.10	8.22	4.1
105	80.5	1254	47.5	859	3.03	58.1	5.52	3.86	1.64	12.3	4.1
96	63.4	1255	52.4	859	2.94	66.1	5.02	3.77	1.25	9.4	3.2
95	34.85	1255	42.85	853	2.13	74.3	3.32	2.60	0.72	5.4	2.5
97	20.65	1255	16.1	852	2.02	84.3	2.74	2.37	0.37	2.8	1.4

[1]) Thermoelektrisch gemessen. [2]) Gesamttemperaturerhöhung des Kalorimeters, Anfangstemperatur 20 bis 20,5°. — [3]) $\Delta\vartheta'$ ist die Temperaturerhöhung durch die Wärmeinhalte von Kupfer und Aluminium: $\Delta\vartheta' = m_{Cu} \cdot \Delta\vartheta'_{Cu} + m_{Al} \cdot \Delta\vartheta'_{Al}$ worin $\Delta\vartheta'_{Al}$ aus Zahlentafel 4 oder Abb. 13 zu entnehmen ist. — [4]) Der Wasserwert des Kalorimeters betrug w = 7,51 ± 0,03 kcal. — [5]) $n_0 = \frac{m_{Cu}}{63.57} : \frac{m_{Al}}{26.97}$. — [6]) 6,9 g Cu, 0,65 g Al haben nicht reagiert.

dem Zustandsschaubild hervor, daß der Mischkristall mit 25 Atom-% Al nur unter einer geringen Aufspaltung schmilzt. Doch bedarf gerade der Konzentrationsbereich von 0 bis 25 Atom-% Al nach den Ausführungen von M. Hansen[22]) noch einer weiteren Nachprüfung. Vom thermochemischen Standpunkt betrachtet sollten die Bindungsverhältnisse in diesem Konzentrationsbereich nicht sehr verwickelt sein. Jedenfalls könnte die Annahme vertreten werden, daß in dem ganzen Bereich von 0 bis 50 Atom-% Al in den Mischkristallgebieten die Verbindungen Ni_3Al und NiAl beständig seien. Der Verlauf der Teilstrecke a b und b c entspricht durchaus noch demjenigen für heterogene Gemenge.

Als Bildungswärmen der Kristallarten (eingeschlossen wurde die zwar nicht als Phase im Zustandsschaubild gekennzeichnete Legierung mit 25 Atom-% Al als Ni_3Al) des Systems Ni-Al ergeben sich aus der Abb. 18 die folgenden Werte:

Uebersichtstafel IV.

a) Unmittelbare Bildung der Nickel-Aluminium-Legierungen aus den Elementen.

Reaktion	Reaktionswärme in kcal für Gramm-Molekül Verbindung	Gramm-Atom Legierung	Gramm-Atom Aluminium	Gramm-Atom Nickel
n Ni + Al → MK*)	...	...	38	—
3 Ni + Al → Ni_3Al	37,6	9,4	37,6	12,5
Ni + Al → NiAl	34,0	17,0	34,0	34,0
Ni + 2 Al → $NiAl_2$	37,8	12,6	18,9	37,8
Ni + 3 Al → $NiAl_3$	38	9,5	12,7	38

*) n > 3, MK = Mischkristalle mit weniger als 25 At.-% Al.

b) Mittelbare Bildung.

Reaktion	Reaktionswärme in kcal
NiAl + 2 Ni → Ni_3Al	3,6
NiAl + Al → $NiAl_2$	3,8
NiAl + 2 Al → $NiAl_3$	4
$NiAl_2$ + Al → $NiAl_3$	4,2
Ni_3Al + 2 $NiAl_3$ → 5 NiAl	57
Ni_3Al + $NiAl_3$ → 4 NiAl	60

Die Zahlenwerte lassen unmittelbar das Zutreffen der gleichen Regel erkennen, die bei den bisher untersuchten Systemen erwähnt wurde, die aber unmittelbarer schon aus der Bildungswärme-Konzentrationsbeziehung zu folgern ist. Die Wärmetönung der unmittelbaren Bildung der Nebenverbindungen aus den Elementen sind um ein Vielfaches höher als diejenigen ihrer mittelbaren Bildung aus der Hauptverbindung NiAl durch Hinzutreten von Nickel oder Aluminium. Die mittelbare Bildung der Hauptverbindung aus den Nebenverbindungen erfolgt stets unter großer Wärmeabgabe.

Die Mischungswärmen der Schmelzen wurden nicht bestimmt. Sie können aber nicht erheblich kleiner sein als die Bildungswärmen der Legierungen. Darauf weisen die großen Temperatursteigerungen beim Zusammengießen der beiden Metalle hin.

VI. Die Bildungswärmen der Kupfer-Aluminium-Legierungen und -Schmelzen.

Die Bedeutung der Kupfer-Aluminium-Legierungen für die Entwicklung der Technik der Nichteisenmetalle, in der die aluminiumreichen Legierungen als aushärtbare Werkstoffe oder die kupferreichen als Aluminiumbronze Verwendung finden, deren Festigkeitseigenschaften denen der Zinnbronze nicht nachstehen, braucht nicht hervorgehoben zu werden.

Auch die große Zahl der Veröffentlichungen über das Zustandsschaubild und die Eigenschaften dieser Legierungen weist auf ihre Wichtigkeit hin. Ueber ihre Bildungswärmen, die sowohl für die technische Erschmelzung als auch für die Beurteilung ihrer Eigenschaften wertvolle Anregungen gestatten, liegen Versuchsergebnisse im Schrifttum nicht vor, obwohl ihre unmittelbare Bestimmung äußerst einfach ist.

a) Die Bildungswärmen der Legierungen bei 20°.

Als Ausgangsstoffe für die Bildung der Legierungen dienten Leitungskupfer und das bereits gekennzeichnete Hüttenaluminium. Das Leitungskupfer wurde bei 1250 bis 1300° in Graphittiegeln unter zeitweiligem Rühren mit

TRANSLATION E 151

Excerpt from: (illegible)

"ZUR THERMOCHEMIE DER LEGIERUNGEN I"

by Willy Oelsen and Walther Middel

IV-2

Pages 13 - 16:

V. Heat of Formation of Nickel-Aluminum Alloys

Aside from the more qualitative statement by A.G.C. Gwyer[15] that, when jointly heating nickel and aluminum, the reaction takes place even more violently and with a greater temperature increase than when heating cobalt and aluminum, which will be confirmed, there are no numerical values available in the literature.

A nickel cube (99% Ni, 0.3% Fe, <0.1% Co and approx. 0.2% C prior to remelting) is used. Following remelting, the carbon content dropped to below 0.02%; also, a portion of the iron and of the cobalt was reduced to slag. As aluminum, there was used again the primary aluminum as characterized in the previous sections. The remelted nickel was carefully deoxidized prior to pouring off (casting) by means of a glass rod and by adding 0.5% Mn. Such a deoxidation is absolutely necessary since at 1,600° the nickel is able to dissolve up to 4.5% NiO from its silicates. A high oxide content of the nickel could falsify the heat of formation particularly of nickel-aluminum alloys considerably since the reaction

$$3\ NiO + 2\ Al \longrightarrow 3\ Ni + Al_2O_3$$

yields the very large quantity of heat of 205 kcal corresponding to the difference between the heat of formation of alumina and that of nickel(II)oxide. This additional heat effect in the case of oxide-containing nickel melts should appear especially clearly in the first small aluminum amounts. In the experiments dealt with in this paper such observations were not made; the deoxidation of the nickel melts by means of the lime silicate slag and the addition of manganese was obviously sufficient.

DEFENDANT'S EXHIBIT IV-2 NO.

Even without any measurement it was observed that, upon pouring nickel (1,600°C) into liquid aluminum (850°), the reaction yields a much higher temperature of the mixture than upon the addition of cobalt. The mixture lights up to produce a glaring white even when seen through rather dark protective glasses. When using equivalent amounts of aluminum and nickel, temperatures of close to 2,000° should be reached in spite of a considerable heat loss resulting from the previously cold crucible. It is certain that the crucible was heated to more than 1,650°C in the reaction zone since its fragments (body?) was sintered in a glass-like manner and also showed signs on the inside of fusing off. The short duration of the increase in temperature was sufficient to reduce up to 2% Si from the crucibles by means of the aluminum, but only in the case of melts having approx. 50 atom % Al, where the highest final temperatures are reached. A part of the experiments using approx. 50 atom% Al was therefore repeated with crucibles having a high content in alumina (> 80% Al_2O_3) in the reaction vessel. The silicon contents remained below 0.5 %, but the reaction heat was not noticeably less than when using sand crucibles. The silicon contents of the alloys were neglected when calculating the heat of formation.

Table 6 shows the results of the experiments including all data necessary for the calculation, arranged according to increasing aluminum contents of the alloys. The values for the heat contents of the aluminum can again be seen from table 4 and/or fig. 13. Regarding the heat content of the deoxidized nickel, experiments 61 and 62 yield the value of (293 + 1) cal/g for 1,600°C (20°), which is however by about 2% higher than the data given in the literature showing a mean of 283 cal/g. The calculations were of course based on our own value determined under the same experimental conditions.

The comparison of columns 9 and 10 of table 6 shows directly the magnitude of the heat of reaction as compared to the heat quantities put in as heat contents by the liquid aluminum and the

liquid nickel. Even at 5.3 atom % Al (experiment no. 59) the reaction heat is more than 12 % of the sum of the heat contents, at 45.9 atom % Al the reaction heat is already 130 % of the heat contents put in.

Fig. 18 shows the heat of formation of the nickel-aluminum alloys per gram-atom as a function of the aluminum content (in atom %). Through the experimental points a trace a b c d e can be drawn which at point c, at 50 atom % Al, has a sharp peak and only slightly marked breaks at points b (at approx. 25 atom % Al), d (at approx. 67 atom % Al). Other characteristic concentrations cannot be derived from the experimental points with certainty. The relationships between heat of formation and concentration are thus similar to those in the system Co-Al (fig. 16), but substantially different from those in the system Fe-Al (fig. 14). The trace a b c d e is nearly symmetrical with respect to the vertical at 50 atom %, the alloys rich in aluminum exhibit an only slightly greater heat of formation (per gram-atom Al) than those rich in nickel (per gram-atom Al). The heat of formation of the nickel-aluminum alloy having 50 atom % exceeds the one corresponding thereto in the system Co-Al by approx. 4 kcal per gram-atom of alloy, and the one corresponding thereto in the system Fe-Al even by approx. 11 kcal per gram-atom.

The heat of formation - concentration relationship of fig. 18 corresponds completely to the data provided by the phase diagram[22] Ni-Al (fig. 13) with respect to the concentrations and also with respect to the stability of the various phases that occur. The compound NiAl is characterized by a particularly high peak of its melting point curve, which passes the melting point of pure nickel by about 190°. [In the phase diagram Co-Al (fig. 17) this difference is only 140°; in the phase diagram Fe-Al (fig. 15) solidification at 50 atom % Al does not start till 1,330°, i.e. 200° below the melting point of iron.] Compared thereto, the compounds $NiAl_2$ (at 1,132°) and $NiAl_3$ (842°) melt at a much lower temperature with decomposition. It is therefore understandable that, compared to the compound NiAl, these

compounds do not appear as markedly on the section c d e of the heat of formation - concentration trace.

The break b at approx. 25 atom % Al is close to the eutectic point of the α and β mixed crystals (crystalline solid solutions?) found at 1,370° by A.G.C. Gwyer; it is also evident from the phase diagram that the mixed crystal having 25 atom % Al melts with only slight cleavage. But, according to M. Hansen's[22] statements, it is the concentration range from 0 to 35 atom % Al that requires further research. From the thermochemical point of view, the bond relationships in this concentration range should not be very complex. At any rate, it could be assumed that in the entire range from 0 to 50 atom % Al in the mixed crystal zones the compounds Ni_3Al and NiAl are stable. The course of the section a b and b c corresponds definitely still to that for heterogenous mixtures.

The following values result from fig. 18 as heat of formation of the crystal types (including the alloy having 25 atom % Al as Ni_3Al which was not marked as phase in the phase diagram): (see table IV).

The numerical values indicate that the same rule proves to be correct that was mentioned regarding the hitherto tested system but that can be directly derived from the heat of formation - concentration relationship. The heat effect of the direct formation of the secondary compounds from the elements is higher by a multiple than those of its indirect formation from the main compound NiAl by addition of nickel or aluminum. The indirect formation of the main compound from the secondary compounds occurs always with great heat emission.

The mixture heat of the melts was not determined. But it could not be considerably smaller than the heat of formation of the alloys. This fact is indicated by the temperature increases upon pouring the two metals together.

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15) M. Hansen: Der Aufbau der Zweistofflegierungen, Berlin: Julius Springer, 1938, pp. 168/15

21) Cf., for instance, W.P. Sardenheuer and E. Brauns: Mitt. Kais.-Wilh.-Inst. Eisenforsch., Duesseld., 17 (1935), pp.127/32, as well as W. Oelsen and G. Kremer: Mitt. Kais.-Wilh.-Inst. Eisenforsch. Duesseld. 18 (1936), pp. 89/108

22) Taken from H. Hansen: Der Aufbau der Zweistofflegierungen, Berlin Julius Springer, 1936, pp. 137/40.

Figures and Tables

Fig. 16: Heat of formation of cobalt-aluminum alloys at room temperature per gram-aton (table 5) ⊙ values according to W. Klitz and W. Wolverscheidt.

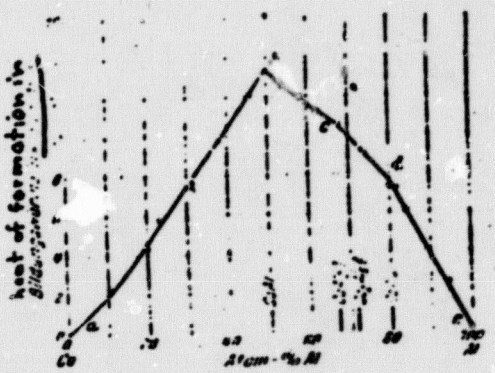


Fig. 17: Phase diagram cobalt-aluminum

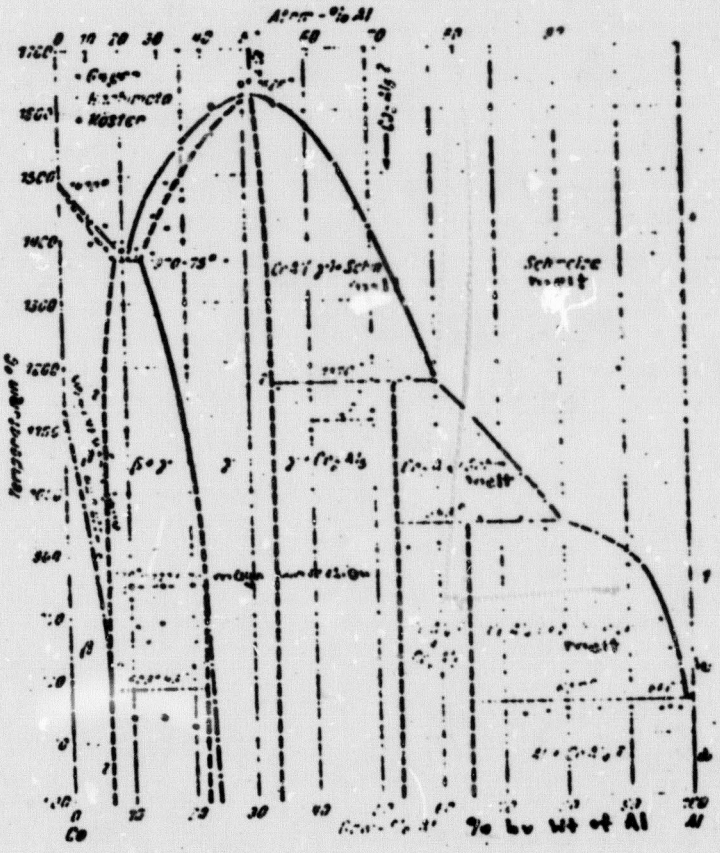


Fig. 18: Heat of formation of nickel-aluminum alloys at room temperature per gram-aton (table 6)

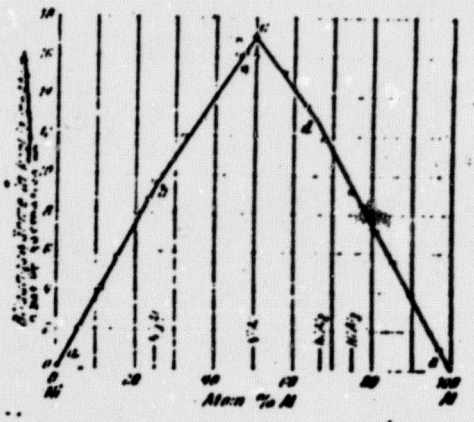
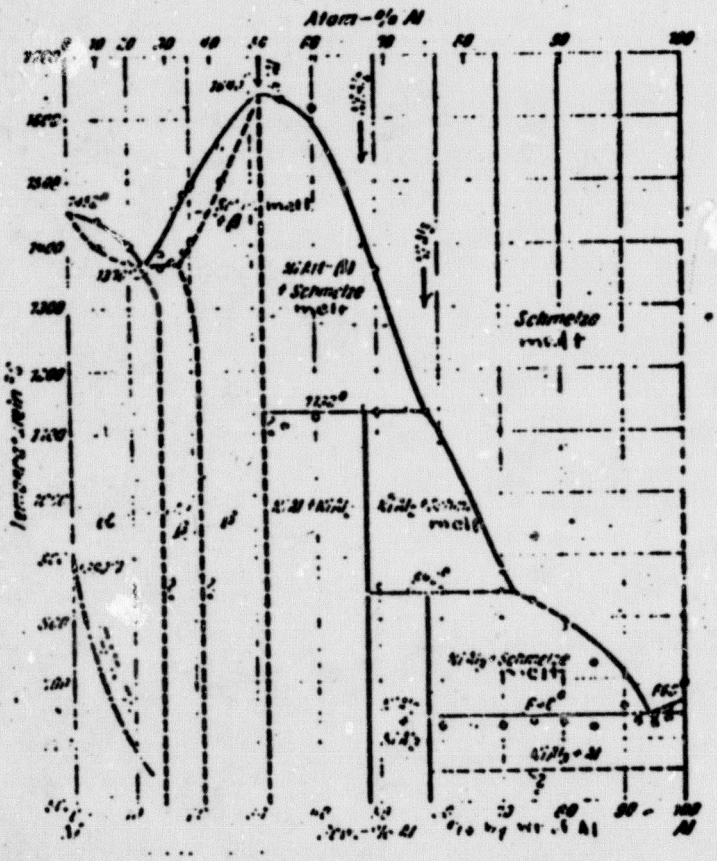
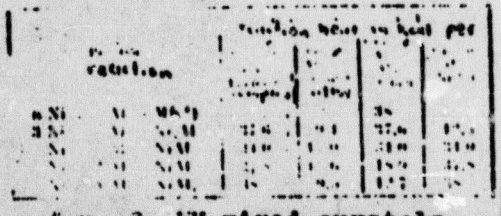


Fig. 19: Phase diagram nickel-aluminum

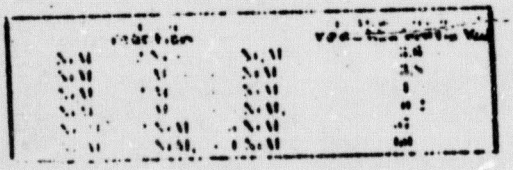


Tabel IV

a) Direct formation of the nickel-aluminum alloys from the elements



b) Indirect formation



* n [illegible]. MX mixed crystals having less than 25 atom % Al

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THE HEATS OF FORMATION IN THE SYSTEM ... ALUMINIUM + NICKEL + TITANIUM*

By O. Kubaschewski

Received 13th December, 1957

The heats of formation of 49 ternary and 27 binary alloys in the ni... + titanium + ...luminium system from the component metals have been determin...d experimentally by means of a calorimeter described previously. From the results the isoth... diagram has been drawn, and some information on the phase diagram has also been obtained from the heat-of-formation curves as well as from X-ray analyses.

Thermodynamic data of alloy systems are required for the more accurate determination of equilibrium diagrams, the assessment of p... production methods of alloys from ores, and the study of the reasons for the relative stability of intermetallic phases. The data for binary metallic systems are now being slowly accumulated, but very little is as yet known about the thermodynamic properties of ternary metallic systems. A few ternary systems of iron metals were studied by Oelsen and Lichtenberg[1] who poured molten alloys (e.g. Fe + Ni) and a molten metal (e.g. Al) into a calorimeter where the mixture was allowed to cool to room temperature, and the heats of formation were obtained by subtracting the heat contents of the components from the measured heat effects. Measurements of the electromotive forces between liquid ternary alloys of low melting point, such as Cd + Pb + Sn or Zn + Sn + Sb, and the base metal of the alloys have been carried out at the Massachusetts Institute of Technology[2] and at Modena University.[3] E.m.f. as well as vapour-pressure measurements were used by Halla[4] and his associates to study the liquid systems Na + Cl + Hg and Na + Hg + Pb, and Argent and Wakeman[5] recently published an investigation of the systems Cu + Zn + Ga and Cu + Zn + Ge by means of the dew-point method.

All these measurements deal with the thermochemical effects of adding one metal to a binary or ternary alloy. The present paper gives the heats of formation on direct combination of three different metals. The system aluminium + nickel + titanium was selected, first, because the heats of formation of the binary alloys were already known, and secondly, because it was hoped the results might form the basis for further assessments and considerations, on the grounds that it was believed the system was simpler than it turned out to be.

EXPERIMENTAL

A detailed description of the calorimetric method used has already been published.[6] In principle a mixture of the powders of two or three components is heated by a small furnace within the calorimeter until alloying takes place rapidly. The electrical energy supplied is measured by a watt-hour meter. When the calorimeter has again at 25°C, an amount of electrical energy is put into the furnace which raises the calorimeter block to the same maximum temperature as in the reaction run; the difference between the input electrical energy in the reaction- and calibration-runs is then the energy evolved by the reaction.

With the titanium + aluminium alloys the temperature did not rise to the melting point of the alloys. Most of the nickel + titanium as well as the ternary alloys, however, melted so that the compacts had to be encased in molybdenum crucibles. The weight of

* Communication from the National Physical Laboratory.

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... was about 36 g and their heat capacity approximately equal to that of the compacts. The corresponding loss in accuracy was compensated by the use of a precision grade ... rating current watt-hour meter made by Chamberlain and Hookham Ltd. and tested by the Electricity Division of the National Physical Laboratory which estimated its ... acy to ± 0·2 %.

Spontaneous reaction usually set in when the compacts had reached a temperature ... ween 730° and 850°C, and the temperature then rose to between 1000° and 1250°C, ... occasionally even to above 1300°C, depending on the heat of reaction and the ... perature of spontaneous reaction.

Some of the alloyed specimens were powdered, annealed (10 min), and examined by an X-ray diffraction method using a standard 19 cm camera and nickel-filtered copper radiation. The exposure time was 3 h.

RESULTS

The experimental heats of formation in the binary systems nickel + aluminium and nickel + titanium, and the ternary system nickel + titanium + aluminium are given in table 1; those in the system titanium + aluminium were recorded previously.[6] The results for the nickel + titanium system were also published before,[7] but only in the form of a diagram and they are therefore incorporated in table 1. Oelsen and Middel[8] measured heats of formation in the nickel + aluminium system by pouring the two metals, separately heated above their melting points, into a calorimeter, where they were stirred while still liquid and allowed to cool. The present results are numerically lower than Oelsen and Middel's by 10 % or less, that is just within the claimed accuracy of Oelsen's method. With that method some oxidation is likely to occur, and, in addition, a technical grade of nickel had to be used the oxygen content of which was not known so that no correction was made for the heat effect of oxygen passing from nickel to aluminium. It is therefore reasonable to assume that Oelsen and Middel's results were somewhat too high.

TABLE 1.—EXPERIMENTAL HEATS OF FORMATION OF NICKEL + TITANIUM + ALUMINIUM ALLOYS

atomic %			$-\Delta H_f$	no. of phases present[a]
Ni	Ti	Al	cal/g atom	
92·8	7·2	0	1930	one: Ni [ref. 16]
91·5	8·5	0	2710	one: Ni [10]
90·4	9·6	0	2910	one: Ni [10]
89·2	10·8	0	3240	two: Ni + Ni_4Ti [10]
88·0	12·0	0	3650	two: Ni + Ni_4Ti [10]
86·8	13·2	0	4700	two: Ni + Ni_4Ti [10]
85·7	14·3	0	4710	two: Ni + Ni_4Ti [10]
83·4	16·6	0	4270	two: Ni + Ni_4Ti [10]
75·0	25·0	0	5640	two: Ni + Ni_4Ti [10]
75·0	25·0	0	8240	one: Ni_3Ti [10]
50·0	50·0	0	8420	one: Ni_3Ti [10]
50·0	50·0	0	8070	one: NiTi [10]
33·3	66·7	0	8120	one: NiTi [10]
33·3	66·7	0	6510	one: $NiTi_2$ [10]
10·0	90·0	0	6200	one: $NiTi_2$ [10]
10·0	90·0	0	2260	two: $NiTi_2$ + Ti [10]
10·0	90·6	0	2210	two: $NiTi_2$ + Ti [10]
6·65	93·35	0	1230	two: Ti + $NiTi_2$
6·65	93·35	0	1580	two: Ti + $NiTi_2$
90·0	6·0	4·0	2660	
90·0	6·0	4·0	2900	
75·0	20·0	5·0	8770	two: Ni_3Ti + Ni_3Al [9]
45·0	50·0	5·0	8420	(three) [ΔH]
90·0	4·0	6·0	2300	one: Ni [9]
75·0	15·0	10·0	8900	one: Ni_3Al [9]
50·0	40·0	10·0	10100	(two) [ΔH]; two: NiTi + Ni_2TiAl [9]
40·0	50·0	10·0	9020	(three) [ΔH]
75·0	10·0	15·0	9000	one: Ni_3Al [9]

TABLE 1.—(*contd.*)

atomic % Ni	Ti	Al	$-\Delta H_f$ cal/g atom	no. of phases present*
35·0	50·0	15·0	9470	three: $NiTi_2$ + Ni_2TiAl + (NiTi) [*r*]; three [*m*]
80·0	0	20·0	7010	two: Ni + Ni_3Al [11]
75·0	5·0	20·0	9100	one: Ni_3Al [9]; one [ΔH]
60·0	20·0	20·0	11600	two: Ni_3Al + Ni_2TiAl [9]; (two) [ΔH]
50·0	30·0	20·0	12130	(two) [ΔH]
30·0	50·0	20·0	9670	
20·0	60·0	20·0	8000	(three) [ΔH]
50·0	25·0	25·0	13100	one: Ni_2TiAl [9]; one [*m*]; one [ΔH]
25·0	50·0	25·0	9670	(two) [ΔH]
70·0	0	30·0	10310	two: Ni_3Al + NiAl [11]
60·0	10·0	30·0	11590	(three) [ΔH]
60·0	10·0	30·0	11200	(three) [ΔH]
50·0	20·0	30·0	13790	one [ΔH]
40·0	30·0	30·0	12920	one [ΔH]
30·0	40·0	30·0	11140	(two) [ΔH]; two [*m*]
20·0	50·0	30·0	9440	three: αTi + Ni_2TiAl + ($NiTi_2$) [*r*]; two [*m*]
15·0	50·0	35·0	9830	(two) [ΔH]
60·0	0	40·0	12060	one: NiAl [11]
55·0	5·0	40·0	12470	(two) [ΔH]
50·0	10·0	40·0	13850	(two) [ΔH]
45·0	15·0	40·0	13010	(two) [ΔH]
40·0	20·0	40·0	(12950)	
30·0	30·0	40·0	12070	(two) [ΔH]
20·0	40·0	40·0	10810	three: TiAl + Ni_2TiAl + (αTi?) [*r*]; (three) [ΔH]
10·0	50·0	40·0	9370	(two) [ΔH]
5·0	50·0	45·0	9100	
50·0	0	50·0	14050	one: NiAl [11] [9]
45·0	5·0	50·0	13890	two: NiAl + (Ni_2TiAl) [*r*]; (two) [ΔH]
45·0	5·0	50·0	13730	(two) [ΔH]
40·0	10·0	50·0	13700	one [ΔH]
35·0	15·0	50·0	(12680)	
30·0	20·0	50·0	12450	three: NiAl + Ni_2TiAl + TiAl [*r*]
25·0	25·0	50·0	12450	
20·0	30·0	50·0	12020	three: TiAl + Ni_2TiAl + (NiAl) [*r*]; one [ΔH]
15·0	35·0	50·0	11050	one [ΔH]
10·0	40·0	50·0	10020	
5·0	45·0	50·0	9020	
45·0	0	55·0	14070	one: NiAl [11]
40·0	0	60·0	(13780)	one: Ni_2Al_3 [11]
30·0	10·0	60·0	12340	(two) [ΔH]
20·0	20·0	60·0	10820	(two) [ΔH]
35·0	0	65·0	12050	two: Ni_2Al_3 + $NiAl_3$ [11]
25·0	0	75·0	(9800)	one: $NiAl_3$ [11]
20·0	5·0	75·0	9220	
15·0	10·0	75·0	9310	two: $TiAl_3$ + $NiAl_3$ [*r*]
10·0	15·0	75·0	9480	one [ΔH]
10·0	15·0	75·0	9040	one [ΔH]
5·0	20·0	75·0	8640	(two) [*m*]

* Chemical formulae indicate structures obtained mainly by X-ray analysis, rather than chemical compositions. Parentheses indicate that the X-ray lines characteristic of the phase were very weak.

All the results of table 1 have been described in the earlier paper.[9] The powdered titanium and aluminium [illegible] been distilled 0·1 % carbon; it was [illegible] with dry hydrogen combined oxygen and [illegible] gen contents were impurities, i.e. mainly [illegible] carbon, was due to the aluminium, and [illegible] if passed to be cal/g atom nickel has been subtracted from

The main physical error comes from [illegible] The total error combining for these two [illegible] value, and was generally between ± 130 ca

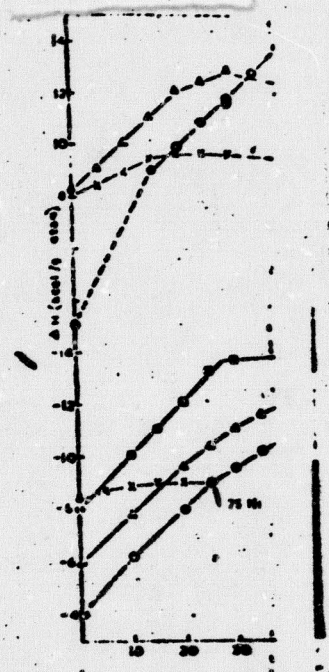


FIG. 1.—Heats of formation of Ni + Ti [illegible] the diagram indi

the error due to incompleteness of reaction [illegible] Since the compacts were at a high temperature for instance, equilibrium should have been in addition submitted to X-ray and micro[illegible] The results are recorded in the last column [*m*] microscopical [illegible] lysis. The phase system being known only in parts, these results correspond to equilibrium conditions probable equilibrium conditions which examinations of the alloys showed no drawing the isocentic lines (fig. 2) some [illegible] formation.

A few results were uncertain because [illegible] These are given in brackets in table 1, [illegible] temperature of 2·5 %.

All the results of table 1 have been corrected for impurity effects in the manner described in the earlier paper.[6] The possible exchange of oxygen and nitrogen between titanium and aluminium has been disregarded. The carbonyl nickel powder contained 0.1 % carbon; it was treated with dry hydrogen at 525 °C and degassed. After this the combined oxygen and nitrogen contents were less than 0.01 %. The correction for these impurities, i.e. mainly the carbon, was calculated to be 150 cal/g atom nickel if passed to the aluminium, and 280 cal if passed to the titanium. An average correction 220 ± 110 cal/g atom nickel has been subtracted from the experimental heats of formation.

The main physical error comes from the watt-hour meter (± 0.2 %, see above). The total error coming from these two sources varied somewhat for each individual value, and was generally between ± 130 and ± 220 cal/g atom alloy. It does not include

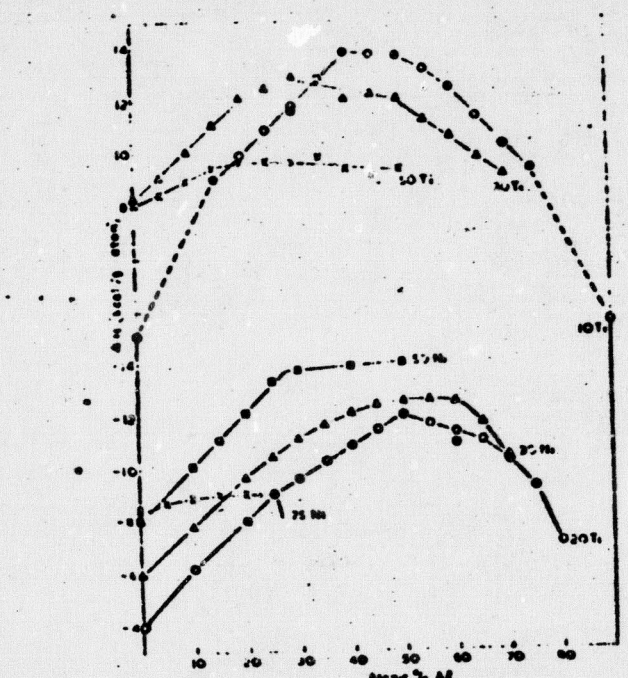


FIG. 1.—Heats of formation of Ni + Ti + Al alloys for various sections. Numbers in the diagram indicate atomic percentages.

the error due to incompleteness of reaction which was also discussed in the earlier paper.[6] Since the compacts were at a high temperature for some time, for 4-7 min above 900 °C for instance, equilibrium should have been approached closely, but several alloys were in addition submitted to X-ray and microscopical analyses after the calorimetric reaction. The results are recorded in the last column of table 1 and indicated by [r] = X-ray or [m] microscopical analysis. The phase diagram of the nickel + titanium + aluminium system being known only in parts, there is no way of ascertaining whether the analytical results correspond to equilibrium conditions, but they are not in contradiction with the probable equilibrium conditions which will be discussed briefly below. The X-ray examinations of the alloys showed no trace of the unreacted metals in any case. In drawing the isenthalpies (fig. 2) some preference has been given to the higher heats of formation.

A few results were uncertain because a short-circuit prevented individual calibration. These are given in brackets in table 1, column 4. The heats of formation are for an average temperature of 275 °C.

The corrected heats of formation have been plotted for a number of sections in various directions across the ternary diagram. Examples are shown in fig. 1. The empty circles, etc., were obtained by interpolation from other curves, and, *vice versa*, the curves of fig. 1 may be used to obtain further values by interpolation.

The isoenthalpies, curves for equal heats of formation, have been obtained from the sectional curves and are plotted in fig. 2. The phase NiAl has the, numerically, highest heat of formation. No phase of particularly high stability seems to exist in the ternary range. The isoenthalpies stretch fairly regularly from the NiAl phase, but bulge out towards Ni_3Ti, NiTi and $Ti_{0.9}Al_{0.1}$, the last two being the two binary phases with maxima in their respective enthalpy diagrams. $NiTi_2$ also has a small effect on the isoenthalpies.

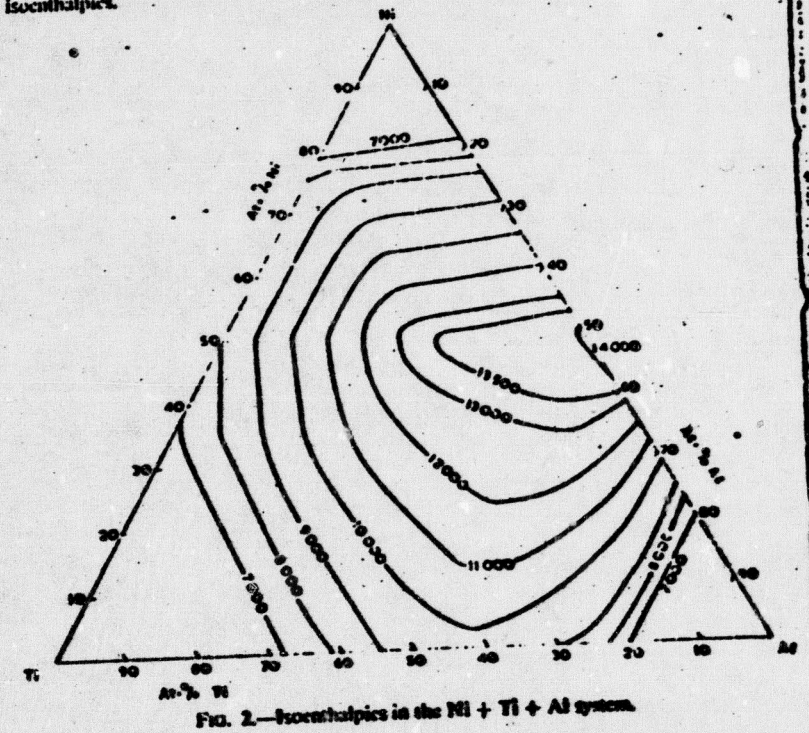


FIG. 2.—Isoenthalpies in the Ni + Ti + Al system.

PHASE RELATIONSHIPS

The binary phases alone contribute a total of twelve phases to the ternary system. When this work was begun it was expected that NiAl and NiTi form a continuous series of solid solutions, both phases having the b.c.c. structure of the CsCl type and the lattice constants differing by less than 5 %. However, Taylor and Floyd[9] studied the nickel corner of the system with specimens quenched from 750° to 1150° C by X-ray methods and micro-examination and found that the NiAl + NiTi section consists of three phases, NiAl, Ni_2TiAl and NiTi. This result has been confirmed by the present X-ray work. Obviously, despite the crystallographic similarity, the band types of NiTi and NiAl are too different to permit a complete mutual solubility.

Where Taylor and Floyd investigated compositions near the present ones their results on the phases present at 750° C have been incorporated in table 1. The binary equilibrium diagrams are well known. The nickel + titanium diagram of

Poole and Hu[illegible]very[8] and [illegible] the *Institute of* [illegible]erjet[illegible] have the last column [illegible]'s I.

Some additi[illegible] formation [illegible] the heat against [illegible]ntration cur[illegible] the system were [illegible], the constru[illegible] no difficulty. S[illegible]ntropics of te[illegible] curves only can be[illegible]. Any a[illegible]s enthalpy, or e[illegible], must follo[illegible] (e.g. fig. 1) cro[illegible] a three-phase re[illegible] cross a two-pha[illegible]gion they may direction of the [illegible]ation; and in necessarily curved [illegible]. Inflection but are expected to be rare. The curves in the binary sections, por[illegible] indicated in a [illegible] diagram. At intersect should correspond to a ti[illegible] a curved portion a two-phase reg[illegible] curved portion shows the presence however, enthalpy against concen[illegible] also be straight lines only the on[illegible] this method. Concentrations for[illegible] deduced from the [illegible]ional enthalp[illegible]tions are supplemented wi[illegible] this i[illegible] If the curves indicated a point in[illegible] phases has been p[illegible] in brackets. the number of p[illegible]s was obtained[illegible] or microscopic i[illegible]stigations the[illegible] 20 Ni + 30 Ti + 5[illegible]l alloys. The concentration r[illegible]gi[illegible] of not less t[illegible] mated from thes[illegible] measurements [illegible] 5 % in any of [illegible] three directi[illegible] heating (from 4 to 7 min above [illegible] equilibrium by a fe[illegible]percent. This where it was p[illegible]d out that the [illegible]ally have been within the ranges 20 Ni + 37 Ti + 29 Al is probabl[illegible] TiAl + Ni_2TiAl + Ni_2Al and, owi[illegible] of estimating the [illegible]oses gave diffe[illegible]

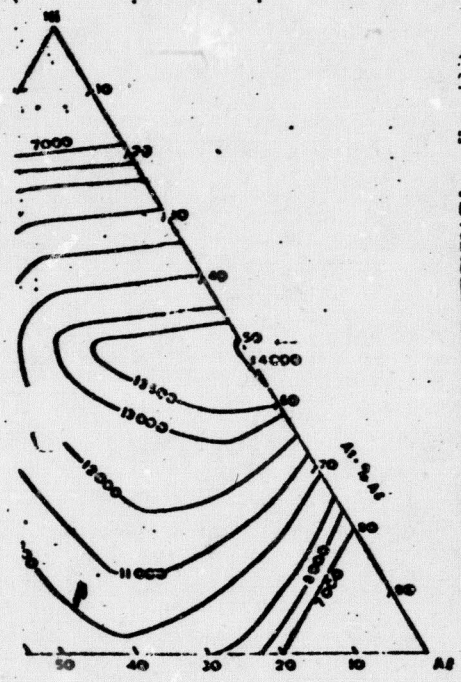
Since the [illegible] nickel + tita[illegible] phases and is consequently usefu[illegible] drawing a tentative phase diagra[illegible] column of table 1 may assist in f[illegible] however, not correctly defined. 278° C, but the equilibrium would[illegible] peratupe, estimated to be between[illegible] perature of Taylor and Floyd's stu[illegible] diagram have also been selected fo[illegible]

The work described above has[illegible] programme of the Metallurgy D[illegible] and this paper is published by per[illegible]

The author desires to acknow[illegible] Sutherland who carried out the e[illegible] the electrical equipment received f[illegible] of the Laboratory.

OF FORMATION

e been plotted f[illegible] a number of sections in various
Examples are shown in fig. 1. The empty circles,
other curves, and, *vice versa*, the curves of fig. 1
interpolation.
heats of formation, have been obtained from the
. The phase NiAl has the, numerically, highest
ularly high stability [illegible] to exist in the ternary
regularly from the NiAl phase, but bulge out
the last two being the two binary phases with
iagrams. $NiTi_2$ also has a small effect on the



s in the Ni + Ti + Al system.

RELATIONSHIPS

ute a total of twelve phases to the ternary
n it was expected that NiAl and NiTi form
both phases having the b.c.c. structure of the
iffering by less than 5 %. However, Taylor
er of the system with specimens quenched
nds and micro examination and found that
three phases, NiAl, Ni_2TiAl and NiTi. This
resent X-ray work. Obviously, despite the
types of Ni_2Ti and NiAl are too different to

ained compositions near the present ones their
°C have been incorporated in table 1. The
known. The nickel + titanium diagram of

Poole and Hume Rothery [10] and the nickel + aluminium diagram as shown in the *Institute of Metals* series [11] have been used for the phase relationships given in the last column of table 1.

Some additional information on the phase relationships may be obtained from the heat against concentration curves. If the free energies of all the phases in the system were known, the construction of the equilibrium diagram would present no difficulty. Since entropies of formation are, however, not yet known the heat curves only can be used. Any additive property in the system, such as the density, enthalpy, or entropy, must follow certain rules. Where the sectional curves (e.g. fig. 1) cross a three-phase region they must be straight lines; where they cross a two-phase region they may be either straight or curved depending on the direction of the section; and in one-phase regions they are usually but not necessarily curved lines. Inflections in the curves are thermodynamically possible but are expected to be rare. The curved and the straight portions of the heat curves in the binary sections, parallel to the three sides, may be assessed and indicated in a ternary diagram. Any concentration at which three straight portions intersect should correspond to a three-phase region. Where a straight intersects a curved portion a two-phase region is indicated, and the intersection of three curved portions shows the presence of only one phase at this composition. Since, however, enthalpy against concentration curves in a homogeneous phase may also be straight lines only the one-phase regions are unambiguously defined by this method. Concentrations for which the type of curvature could be clearly deduced from the sectional enthalpy against concentration curves in three directions are supplemented with this information in table 1, and indicated by $[\Delta H]$. If the curves indicated a point in a two- or three-phase region, the number of phases has been put in brackets. It is seen that for those compositions where the number of phases was obtained from the ΔH curves as well as from the X-ray or microscopic investigations the results agree, with the one exception of the 20 Ni + 30 Ti + 50 Al alloy. Since the heats of formation were determined in concentration steps of not less than 5 atomic % the phase boundaries estimated from these measurements cannot have an accuracy of better than ± 5 % in any of the three directions. On the other hand, the short duration of heating (from 4 to 7 min above 900°C) may not always have led to complete equilibrium by a few percent. This possibility was mentioned in the earlier paper [6] where it was pointed out that the resulting effect on the heat values would generally have been within the estimated limits of accuracy. The composition 20 Ni + 37 Ti + 50 Al is probably very near a corner of the three-phase field TiAl + Ni_2TiAl + NiAl and, owing to their relative inaccuracy, the two methods of estimating the phases gave different results.

Since the system nickel + titanium + aluminium contains at least thirteen phases and is consequently rather complicated the author has refrained from drawing a tentative phase diagram, but the information contained in the last column of table 1 may assist in future work. The equilibrium temperature is, however, not accurately defined. The temperature of measurement was about 275°C, but the equilibrium would have "frozen in" at a somewhat higher temperature, estimated to be between 500° and 700°C, that is about the lowest temperature of Taylor and Floyd's study. The phase boundaries of the binary phase diagram have also been selected for 700°C.

The work described above has been carried out as part of the general research programme of the Metallurgy Division of the National Physical Laboratory, and this paper is published by permission of the Director of the Laboratory.

The author desires to acknowledge the assistance rendered by Mr. E. G. Sutherland who carried out the experimental measurements, and the advice on the electrical equipment received from Mr. A. Felton of the Electricity Division of the Laboratory.

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STRUCTURES OF IRON A
OPPER S

by

National Chemical

Received 2

An electron-diffraction study has b
electrodeposited on Cu (110), (100) and
with either their (211) or (110) plane p
orientations and the way they developed
conditions. The additional orientation
offer alternative ways for deposits to
secondary scattering (dynamical) and al

It is now well-known that the d
stage of its growth is determined prin
more than one orientation was obser
Similar observations led us to make
electrodeposits on the different face

EXP

Cu (110), (100) and (111) faces were
copper, facing and electropolishing the
Layton and Wilman[9]. Iron and chrom
from baths containing (a) $FeSO_4$, (b
CrO_3, 250 g/l. + H_2SO_4, 2·5 g/l. at c.d
The specimens were then washed thor
immediately examined in a Finch type
deposit-structures were progressively a
substrate surfaces were also examined.

The diffraction patterns from copp
face) consisting of spots elongated tow
are indicative of smooth and undistort
show that the crystals were of three t
disposed polycrystals and (iii) one-di
types of crystals were present in the de

INITIAL

on Cu (110) face

The deposits of iron obtained in
two-degree orientated crystals, somet
pattern (fig. 2) shows a hexagonal netw
in the plane of incidence (beam along
grew epitaxially with their (211) plane
of the copper. The pattern (fig. 3)
mainly a rectangular spot pattern with
the diagonals at 1/3 and 2/3 distances
deposits with the electron beam simulta

E 165

THERMOCHEMICAL DATA OF ALLOYS

by

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and

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NO. IX

E 165-1

PANIGEN

TECHNICAL BULLETIN 561

BENEKE

DX
KB

E 165-2

Kanigen®

chemically deposited nickel alloy coating

The Kanigen process is a method for depositing a uniform, hard, corrosion- and abrasion-resistant nickel alloy coating on iron, copper, aluminum, titanium and their alloys without the use of electricity. The coating exhibits many desirable properties not normally associated with metals or metal plating.

On the basis of electron and x-ray diffraction studies, Kanigen nickel alloy coatings, as deposited, have the characteristics of an under-cooled liquid. The as-plated coating exhibits no detectable crystal structure which undoubtedly accounts for the virtually zero porosity. Metallographic studies show that the structure of a Kanigen nickel alloy coating is unaffected by the nature of the substrate. It is not affected by the coating thickness. The growth of a Kanigen deposit originates from multitudinous point sources, or catalytic centers, on the surface of the basis material. From these point sources, coating growth proceeds at equal rates in all directions. On a properly prepared surface, the number of nuclei is so large that growth proceeds as a series of plane fronts parallel to the original surface, thereby producing a uniform thickness regardless of the contours of the part.

Kanigen nickel alloy coatings are free of voids. The conformity to the substrate is so excellent that there is no observable void between the coating and the basis material. Only gross aberrations of the basis material surface which prevent proper pretreatment or act as gas pockets can produce a pore. Otherwise the coating is pore free.

The actual condition of the surface is important as discussed later. Very rough surfaces may be difficult to clean and may actually have small pockets which act as gas traps. On such very rough surfaces it may be desirable to apply coatings in the order of 0.001 inches to 0.002 inches to achieve the porosity-free coating given by a very thin coating on a highly polished surface.

When coated over a highly polished plane surface, the unevenness of the coating itself has been measured to be between 5% and 10% of the thickness of the coating.

**Kanigen is a trademark which identifies chemical nickel coating by General American Transportation Corporation and its licensees, the product resulting therefrom and compositions produced by them for use in chemical nickel coating.*

A number of tests have been made to determine the position of Kanigen, at least relatively, in the electromotive series. These tests were performed by checking the galvanic currents between Kanigen nickel alloy coated parts and bare metal parts of steel, aluminum and stainless steel in aerated 3% salt solution and in hot, aerated tap water. In the salt solutions, the measured currents for Kanigen nickel were slightly less than for electroplated nickel showing that Kanigen nickel-alloy is somewhat less electronegative than electroplated nickel. The corrosion current, and consequently the rate of corrosion of the basis metal, should be somewhat less with Kanigen nickel alloy than with electroplated nickel. In aerated hot water, there appears to be a fairly striking difference in favor of Kanigen nickel alloy. In this case, the corrosion currents were significantly less for Kanigen nickel alloy than for electroplated nickel.

Chemical analysis

The average chemical analysis of Kanigen nickel alloy is as follows:

NICKEL	90-92%
PHOSPHORUS	8-10%
CARBON	0.0400%
OXYGEN	0.0023%
NITROGEN	0.0047%
HYDROGEN	0.0016%

Plus trace impurities of cobalt, aluminum, copper, manganese, iron, lead and silicon.

Specific gravity

The specific gravity of the Kanigen nickel alloy coating, determined with an accuracy of 0.5%, is 7.9. The specific gravity of the recrystallized coating after being heated for one hour above 400°C was measured as 7.8. One pound of the coating, as-plated, corresponds to 24.5 mil square feet.

Melting point 1635°F (890°C)

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Electrical resistivity

approximately 60 micro-ohms/cm/cm²

Coefficient of expansion

13 x 10^{-6} cm/cm per °C or 7.22 x 10^{-6} in/in per °F

Thermal conductivity

in the order of 0.0105 to 0.0135 cal/cm sec °C (calculated)

Hardness and ductility

ROOM TEMPERATURE

The normal hardness as-plated (measured at room temperature), averages about 500 Vickers hardness number, about 49 Rockwell C. In this condition the coating is amorphous and exhibits the characteristics of a super-cooled liquid. Hardness measurements are made on chemical nickel coatings by means of a micro hardness tester of which there are several satisfactory machines on the market. The hardness testing machine makes a small (micro) indentation in the coating under light loading. This indentation is measured and the readings converted to standard hardness numbers. It is very important, in obtaining hardness readings on coatings, that the sample have a sufficient thickness. If readings are taken on coatings less than 3 mils thick, considerable error will be encountered because of basis metal effects. It is preferred to have at least a 5 mils thick coating to determine hardness by means of a diamond indentor.

Heat treatment at 752°F (400°C) 1 hour causes a finely dispersed precipitation of a nickel phosphide (Ni_3P) in the nickel-phosphorus matrix. The result is an increase in hardness to approximately 1000 Vickers, about 70 Rockwell C. The coating, however, is quite brittle in this state of maximum hardness. It is recommended that in those cases where parts are subject to high loads or the possibility of damage from impact, the heat treatment be carried out on the descending portion of the curve e.g. (500°C-600°C).

Kanigen nickel alloy plated on steel can support 2.2% total strain (under load) without showing surface cracks. The ability to support plastic strain is increased to 6% after heat treating the coating at 750°F for ¼ hour, and even more by heat treating the coating to 1550°F.

ELEVATED TEMPERATURES

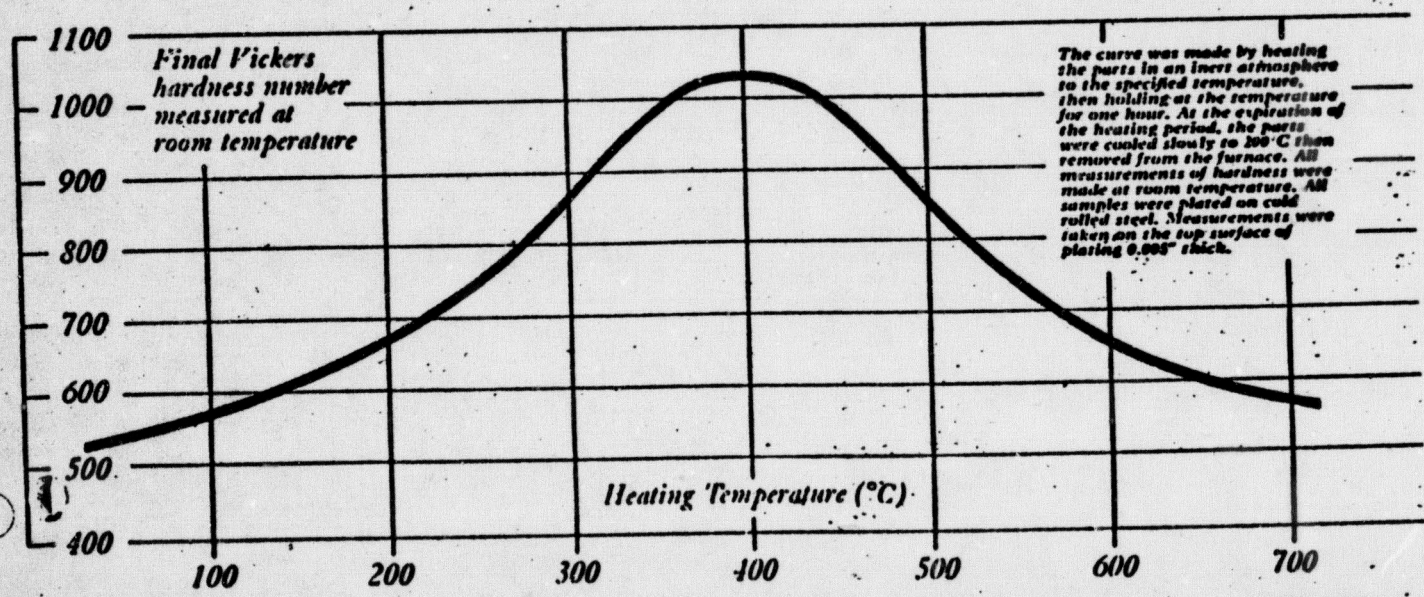
The coating hardness at elevated temperatures is given below.

TEST TEMPERATURE °F	VICKERS HARDNESS NUMBER
750	320
900	230
980	160
1100	too soft for reliable measurement

At elevated temperatures, tests of Kanigen nickel alloy coatings on mild steel specimens stressed in tension to fracture yield the following data.

TEST TEMPERATURE °F	STRAIN TO CAUSE CRACKS IN COATING
800	2.5% elongation
1000	4.0% elongation
1200	cracks only in neck area of specimen after fracture
1400	

Heat treatment curve of Kanigen chemical nickel alloy coating



Frictional properties

Tests involving various metal-to-metal systems under non-lubricated and boundary lubricated (chlorinated paraffin) conditions show the following results:

KANIGEN NICKEL ALLOY (KNA)

SYSTEM	UNLUBRICATED	LUBRICATED
Chrome vs. Steel	0.19 - 0.23	0.13 - 0.12
Chrome vs. KNA	0.43	0.30
Nickel vs. KNA	galling	0.26
Steel vs. KNA	0.38	0.21
Kanigen vs. KNA	0.45	0.25
Chrome vs. Chrome	0.43	0.26
Steel vs. Steel	galling	0.20
Nickel vs. Nickel	galling	galling
Chrome vs. Nickel	galling	0.20
Steel vs. Nickel	—	0.20

Abrasion resistance

The coating provides good abrasion resistance if lubrication is involved or if the surface temperature is not unduly high. Laboratory indices of abrasion resistance must be used cautiously since there are many variables that affect abrasion or wear resistance. The only satisfactory test is actual operation under service conditions.

For comparison purposes, abrasion tests made on the Taber Abrader using a CS-10 wheel and a 1000 gm load for 5000 cycles gave the following wear index numbers:

a. Hard chromium plating	2.0
b. Electrolytic nickel (Watt bath)	14.7
c. Kanigen nickel alloy—as-plated	9.6
d. Kanigen nickel alloy—heat treated at 392°F	8.7
e. Kanigen nickel alloy—heat treated at 572°F	4.4
f. Kanigen nickel alloy—heat treated at 752°F	3.2
g. Kanigen nickel alloy—heat treated at 932°F	2.7
h. Kanigen nickel alloy—heat treated at 1200°F	1.3

The lowest Taber Wear index number indicates the greatest resistance to wear.

Porosity

On well machined and prepared parts plated under laboratory conditions, Kanigen® nickel coatings will have zero porosity when checked by any known industrial porosity test. Kanigen nickel coatings applied in large commercial plating plants to mass produced parts will have an unusually low porosity when compared to other metallic coatings.

The quality of the coating is quite dependent upon the surface to which it is applied. Ideal or near ideal coatings can be obtained only when plating very smooth surfaces on metallurgically homogeneous parts.

Salt spray resistance

A test commonly applied to nickel coatings is the salt spray test ASTM-B-117-49T. Kanigen nickel alloy coatings on cold rolled steel withstand exposure for more than double the time required by the test specifications.

Coatings .001 in. thick on cold rolled steel do not show rust for 96 hours or more. Coatings 0.0005 in. thick on cold rolled steel do not show rust for 64 hours or more. When failure finally occurs, the rust spots show no tendency to spread even when the part is left in the salt spray chamber for as long as 1000 hours.

The character of the surface is an important factor. Results better or worse than those just indicated may occur where very homogeneous surfaces or very non-homogeneous surfaces respectively are plated. While practically all plating experts agree this test is not indicative of porosity, that it does not correlate with service life, and that results are usually erratic, it is felt by some to be a qualitative indication of corrosion resistance.

We feel that the salt spray test produces corrosion —which always takes the form of pits—by a galvanic type of action. It appears to be a self-accelerating process that actually induces pores or pits. Variations in the basis metal such as slag inclusions can cause poor salt spray results though there is no noticeable effect on aerated hot-water tests.

Adhesion

Adhesion of Kanigen nickel alloy coatings is excellent. It is extremely difficult, however, to measure, or to report adhesion since there is no standard quantitative measurement technique for metal coatings. Reported values are in the order of 30,000 to 60,000 psi to steel. Kanigen nickel alloy coated steel specimens show no flaking or chipping of the plating when pulled to the breaking point in tension. When Kanigen nickel alloy plated bars are bent 180°, there will usually be microscopic cracking of the coating parallel to the axis of the bend on the outside of the bend; however, no flaking occurs. Because of its high hardness, a chemical nickel coating will sometimes show compression or shear failure (especially in heavy coatings—1 mil or more thick) on the inside radius of a 180° bend test specimen. This occasionally results in some apparent flaking. Actual microscopic observation, in many cases, has shown that the separation line is in the coating and not between the coat and the basis metal. The adhesive force to the basis metal, in these cases, exceeds the cohesive force of the coating itself.

00646

Effect on mechanical properties of high strength steel

Kanigen nickel alloy plating of SAE 4340 steel specimens treated to 200,000 psi and 260,000 psi produces no effect on tensile strength or ductility of the base material.

The impact energy absorption of SAE 4340 steel specimens treated to optimum Charpy impact resistance is not significantly altered by Kanigen nickel alloy coating.

Kanigen nickel alloy plating plus baking for hydrogen relief reduces the fatigue endurance limit of SAE 4340 R. R. Moore reverse bending specimens by 25%.

Basis metals that can be Kanigen nickel alloy coated

WROUGHT IRON

CAST IRON *(machined surfaces coat excellently; the coating on as-cast surfaces may be porous depending on the quality of the casting)*

STEEL *(including stainless steel)*		TITANIUM
COPPER	BRONZE	BERYLLIUM
BRASS	ALUMINUM	NICKEL

Zinc, lead, cadmium, tin, bismuth and antimony cannot be coated and usually prevent coating or cause poor coating on the part with which they are associated if the leaded area is relatively large. This precludes coating on soldered parts using tin or lead solders; however, brazed or silver-soldered parts may be coated.

Corrosion studies of Kanigen chemical nickel alloy plating

It should be kept in mind that commodities listed in the table may vary from batch to batch in trace constituents that could affect corrosion rates. Where large scale use is contemplated specific corrosion data should be obtained for the commodity.

COMMODITIES AND TEST CONDITIONS UNDER WHICH CHEMICAL NICKEL PLATING IS CONSIDERED SUITABLE

Commodity	Test Temp. °F	Aeration		Immersion		Heat Treat		Corr. Rate Mils per Year
		Yes	No	Total	Partial	Yes	No	
Acetaldehyde	150	X			X		X	0.02
Acetone	Room		X	X			X	0.003
Acetylene Brom. + 1% water	Room		X	X			X	None
Acrylonitrile	150	X		X			X	0.016
Allyl Chloride, "Wet"	105	X			X		X	0.17
Ammonium Sulfide	120	X			X		X	0.15
Ammonium Sulfide Thiocyanate	Room		X	X			X	0.171
Amyl Acetate	Room		X	X			X	0.0019
Amyl Chloride	Room		X	X			X	0.013
Beer	45		X	X		X		0.0078
Benzyl Acetate	Room		X	X			X	None
Benzol	Room		X	X			X	0.0016
Benzyl Alcohol	Room		X	X			X	0.0036
Black Liquor Skimmings	Room		X	X			X	0.01
Boraxo Soln., Sat'd.	Room		X	X			X	0.120
Calcium Chloride Sol'n, 48.5%	Room		X	X			X	0.02
Caprolactam Monomer	185	X			X		X	0.03
Caprylic Acid	150 Max	X			X		X	0.06
Carbon Disulfide	Room		X		X		X	None
Carbon Tetrachloride	Room		X	X			X	None
Carbon Tetrachloride	150 Max	X			X		X	0.14
Carbon Tetrachloride + 15% water	150 Max	X			X		X	0.15
Cetyl Alcohol	160		X	X			X	None
Cobalt Linoleate	Room		X	X			X	None
Coconut Oil Fatty Acid, Water Sat'd.	150 Max	X			X		X	0.08
Cresylic Acid	Room		X	X			X	None
Detergent Soln., 5% Tide	Room		X	X			X	0.037
Dibutyl Phthalate	Room		X	X			X	None
o-Dichlorobenzene	150 Max	X			X		X	0.17
p-Dichlorobenzene	250		X		X		X	0.13
Diphenyl	Molten		X	X			X	0.009
Ethyl Alcohol	Room		X	X			X	0.0065
2-Ethyl Hexoic Acid	150 Max	X			X		X	0.02
Ethylene Dibromide	150 Max	X			X		X	0.107
Ethylene Glycol	Room	X		X		X		0.025
Formaldehyde, 37%	Room		X		X	X		0.012
Formaldehyde	Room		X	X			X	0.15
Gasoline	Room		X	X			X	0.022

COMMODITIES AND TEST CONDITIONS UNDER WHICH CHEMICAL NICKEL PLATING IS CONSIDERED SUITABLE *(continued)*

Commodity	Test Temp. °F	Aeration		Immersion		Heat Treat		Corr. Rate Mils per Year
		Yes	No	Total	Partial	Yes	No	
Insectisol	Room		X	X			X	0.008
Lactic Acid, 80%	Room	X		X		X		0.145
Methyl Alcohol	Room		X	X			X	None
Naphtha, Odorless	Room		X	X			X	None
Naphthenic Acid	150 Max	X			X		X	0.02
Naphthenic Acid, Water Sat'd.	150 Max	X			X		X	0.03
Nitration Toluol	150 Max	X		X			X	0.023
Oleic Acid	Room		X	X			X	0.012
Orange Ice., Canned	Room		X	X			X	0.013
Pelargonic Acid	250		X	X			X	0.01
Perchloroethylene	150 Max	X			X		X	0.15
Petroleum—White Oil	Room		X	X			X	None
Petroleum—Sour Crude	Room		X	X			X	None
Polyvinyl Acetate	150 Max	X			X		X	0.05
Refinery Brine Sol'n	Room		X		X		X	No Attack
Resin (Amine)	120	X			X		X	None
Resin (Polyester)	120	X			X		X	None
Resin (Alkyd)	120	X			X		X	0.05
Rosin Size	210	X		X		X		None
Sodium Carbonate, 10%	Room		X	X			X	None
Sodium Hydroxide, 73% (Lab tests)	250	X			X		X	0.07
Sodium Hydroxide, 73% (Lab tests)	250	X		X			X	0.07
Sodium Hydroxide, 73% (Lab tests)	250	X		X		X		0.09
Sodium Hydroxide, 73% (Lab tests)	200		X	X			X	0.01
Sodium Hydroxide, 73% (Lab tests)	200		X	X		X		None
Sodium Hydroxide, 73% (Lab tests)	250		X	X			X	0.01
Sodium Hydroxide, 73% (Lab tests)	250		X	X		X		0.03
Sodium Hydroxide, 50% (Lab tests)	200		X	X			X	None
Sodium Hydroxide, 50% (Lab tests)	200		X	X		X		None
Sodium Hydroxide, 50% (Lab tests)	250		X	X			X	None
Sodium Hydroxide, 50% (Lab tests)	250		X	X		X		None
Sodium Hydrosulfide, 40%	Room	X		X			X	None
Sodium Sulfide	200		X		X		X	0
Sodium Sulfhydrate (sodium hydrosulfide)	120	X			X		X	0.14
Sorbitol	150 Max	X			X		X	0.1
Stearic Acid	158		X	X			X	0.02
Sugar, Liquid	Room		X	X			X	None
Tall Oil Crude	100	X		X			X	0.03
Tall Oil Crude	100	X			X		X	0.03
Tall Oil Fatty Acid	150 Max	X			X		X	0.03
Tall Oil Fatty Acid	150 Max	X			X	X		0.04
Tall Oil, Refined	Room		X	X			X	0.017
Tall Oil Rosin	320		X	X			X	No Attack
Terpinyl Acetate	120		X	X			X	0.007
Trimethylphosphite	125	X			X		X	0.004
Urea, Sat'd. Soln.	Room	X		X		X		None
Urea, Sat'd. Soln.	Room	X		X			X	None
Urea, 25% Soln.	Room	X		X		X		None
Urea, 25% Soln.	Room	X		X			X	None
Water, Deionized	Room	X		X			X	None
Water, Deionized	120	X		X			X	None
Water, Deionized	180	X		X			X	None
Water, distilled	Room		X	X			X	0.029
Wine, Sherry†	Room		X	X		X		0.0041

COMMODITIES AND TEST CONDITIONS UNDER WHICH CHEMICAL NICKEL PLATING IS CONSIDERED OF MARGINAL SUITABILITY

(Under some conditions these can become suitable)

Ammoniated Ammonium Nitrate	Room		X	X			X	0.31
Ammonium Chloride Solution	Room		X	X			X	0.230
Aniline Hydrochloride, Sat'd.	Room		X	X			X	0.468
Beer	45		X	X			X	0.217
Brine (38% salts)	167		X		X		X	0.66
Brine (38% salts)	215		X		X		X	0.48
Butyraldehyde	150	X		X			X	0.2
Chloral, 90%	150 Max	X			X		X	0.3

COMMODITIES AND TEST CONDITIONS UNDER WHICH CHEMICAL NICKEL PLATING IS CONSIDERED OF ORGINAL SUITABILITY

(Under some conditions these can become suitable) *(continued)*

Commodity	Test Temp, °F	Aeration		Immersion		Heat Treat		Corr. Rate Mils per Year
		Yes	No	Total	Partial	Yes	No	
Citric Acid, 5%*	Room	X		X			X	0.0744
o-Dichlorobenzene, plus 5% water	150 Max	X			X		X	0.47
p-Dichlorobenzene, plus 5% water	250		X		X		X	0.31
Lactic Acid, 45%	Room		X	X			X	0.3
Lactic Acid, 80%	Room	X		X			X	0.704
Lemon Jce. (Canned)	Room		X	X			X	0.23
Monochlorobenzene, plus 5% water	150 Max	X			X		X	0.53
Sodium Chloride, 3%†	Room		X	X			X	0.017
Sodium Chloride, 3%†	Room		X	X		X		0.04
Sodium Cyanide, 5%	Room		X	X			X	0.52
Sodium Formate Slurry	150	X		X		X		0.3
Sodium Sulfhydrate (sodium hydrosulfide)	250		X		X		X	0.48
Sorbitol	230		X	X			X	0.2
Tall Oil Crude	350		X	X			X	0.2
Tall Oil Fatty Acid	350		X	X			X	0.2
Trichloroethylene	150 Max	X			X		X	0.20
Trichloroethylene, plus 5% water	150 Max	X			X		X	0.20
Trimethylphosphite, plus 5% water	125	X			X		X	0.3
Wine, Sherry†	40		X		X		X	0.377

*Commodity turns green

†Corrosion rate very sensitive to aeration

COMMODITIES AND TEST CONDITIONS UNDER WHICH CHEMICAL NICKEL PLATING IS CONSIDERED NOT SUITABLE

Acetic Acid, 5%	Room	X		X			X	5.95
Alum	150	X		X			X	Severe
Ammonium Hydroxide, 30% NH_3	Room		X		X	X		Severe
Ammonium Nitrate, 63%	Room		X	X		X		Severe
Ammonium Phosphate, 5%	Room	X		X			X	Severe
Ammonium Sulfate, 5%	Room	X		X		X		Severe
Barium Chloride, Sat'd.	Room		X	X			X	Severe
Benzyl Chloride	Room		X	X			X	1.44
Bleach Liquor	Room		X	X			X	Severe
Boric Acid Soln.	Room		X	X			X	Severe
Calcium Chloride Sol'n, 40%	200		X		X		X	Severe
Calcium Chloride Sol'n, 3%	Room	X		X			X	Severe
Caprylic Acid	300		X	X			X	6
Chromic Acid, Sat'd.	Room		X	X			X	Severe
Cyanamide, Liquid	Room	X		X			X	0.898
Dimethyldithithiocarbamate			X		X		X	Severe
2,4 Dichlorophenol	160	X		X			X	10.9
2-Ethyl Hexoic Acid, Water Sat'd.	150 Max	X			X		X	1.6
Fluorophosphoric Acid	Room		X	X			X	Severe
Hydrochloric Acid Solns. pH 1.5-4.0	Various conditions tested							Severe
Lemon Juice (raw) plus 0.1% Na Benzoate	Room		X	X			X	Severe
Maleic Acid 20% 1% Naphthoquinone	150 Max	X			X	X		Severe
Maleic Acid 20% 1% Naphthoquinone	150 Max	X			X		X	Severe
Monochloracetic Acid Soln.	Room		X	X			X	Severe
Nitric Acid	Room		X	X			X	Severe
Nitrogen Fertilizers	150 Max	X		X		X		4.7
Phosphoric Acid, 85%	140		X	X			X	Severe
Polyvinyl Acetate	200		X	X			X	2.0
Sodium Chloride, 3%	Room	X			X		X	Severe
Sodium Chloride, 3%	Room	X		X		X		Severe
Sulfuric Acid, 1% Concentrated	Numerous conditions tested							Severe
Vinegar	Room		X	X		X		Severe
Wine, Cream Sherry	150 Max	X			X	X		2.5
Wine, Dry Sherry	150 Max	X			X	X		3.0
Zinc Ammonium Chloride	230		X	X		X		Severe

Outdoor Exposure

The type of failure generally experienced with electroless nickel coatings over ferrous alloys is different than that obtained with electroplated nickel. In the former case, pin point rusting usually occurs, and corrosion does not spread out from a failure point. With electroplated nickel there is more of a tendency for individual failure areas to increase in size. With aluminum alloys, blister types of failure are most common with both types of coatings.

Surface roughness of the substratum contributes to failure of the coating. Under identical conditions the smoother the base material, the longer the life of the coating. (Where grease polishing is used to obtain greater smoothness, extra care in pretreatment of the base material is necessary to assure a clean surface.)

Optimum corrosion resistance to outdoor exposure on steel was obtained with the use of post-plating heat treatment for 4 hours at 1400°F and pretreatment of the base metal using a high temperature molten salt bath cycle. To limit rusting to 0.25-0.5 percent of the surface over periods greater than 12 months requires a coating thickness of better than 2 mils.

Non-metals

Most thermoset plastics (such as phenolic, polyester, epoxy and melamine resins), glass and ceramics may be coated by Kanigen processes. While the nickel alloy deposit on non-metallic materials is continuous and adherent, the degree of adhesion obtained does not approach the high level of adhesion of the coating to metals. Roughening of the non-metallic base is necessary to provide a surface suitable for mechanical adhesion of the deposit to the base. If a decorative finish is required, copper, chromium, silver, etc., may be electro-deposited on the nickel alloy.

Chemical nickel alloy plating on the non-metals is available on a license basis. General American Transportation Corporation provides only laboratory scale evaluation facilities for the plating on non-metals.

Surface appearance

Kanigen nickel alloy coatings have exceptional thickness uniformity, therefore, they reproduce the basis surface faithfully. A properly cleaned, polished part will have the same polished appearance after coating.

Kanigen nickel alloy coatings have high reflectance although the color is somewhat darker than familiar electrolytic nickel.

Color-buffing is very easy on Kanigen nickel alloy coatings. Buffing to smooth, or polish is quite difficult, conversely, because of the exceptional hardness of the coating; it cannot be made to "flow" easily. It is desirable to do any necessary polishing prior to coating. Color buffing may be used after coating to give the highest possible luster.

Applications

PROTECTION FROM CONTAMINATION OR IRON PICK-UP

Probably the largest field of application for Kanigen chemical nickel alloy coating is in the prevention of iron pick-up or contamination. Many materials are not corrosive to steel but are easily contaminated or discolored by iron oxides. Kanigen nickel alloy coating gives excellent protection. The Kanigen nickel alloy coating prevents rusting of the steel surface by high humidity air or moisture condensation. This, in turn, protects the material being handled.

Specific equipment examples are:

- Screw conveyors
- Bakery dough troughs
- Tank cars
- Reaction vessels
- Chemical blending tanks
- Drum dryer rolls
- Extrusion press screws
- Valves
- Piping & pipe fittings
- Dry cleaning equipment
- Pumps
- Compressors
- Filters
- Rotary dryers
- Heat exchangers

CORROSION RESISTANCE

Kanigen nickel alloy coatings offer corrosion resistance equal or superior to that provided by wrought or electrolytic nickel.

A Kanigen nickel alloy coating over steel can often do the job of an expensive stainless or clad alloy. Exceptional savings may be made on some difficult-to-fabricate parts such as valves or pipe fittings.

Typical items include:

Valves, pipe, fittings, pumps, filters, autoclaves, compressors, reaction vessels, turbine castings.

Kanigen nickel alloy coating has been utilized to prevent stress corrosion cracking of stainless steel where the affected parts were too complicated to coat by any other method.

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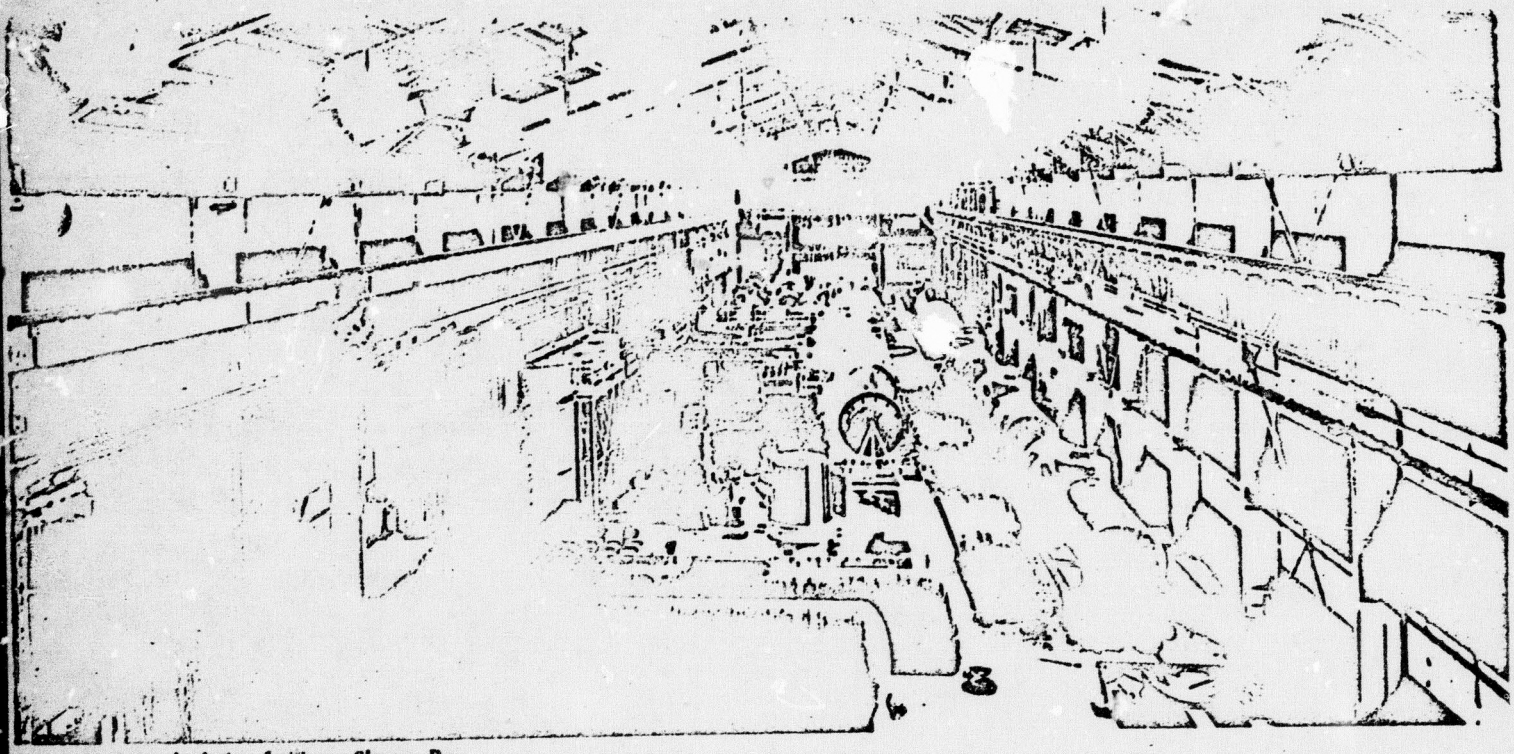


Large tank plating facility at Sharon, Pa.

HARDNESS—WEAR RESISTANCE

The exceptional hardness of Kanigen nickel alloy as-plated, and its heat treatment characteristics make it particularly valuable when wear is a problem. Coupled with its uniformity of thickness, hard Kanigen nickel alloy coatings are excellent for wear surfaces of such items as:

Hydraulic Cylinders	Rotating Shafts
Slides	Pistons
Pumps	Sheaves
Valve Inserts	Rings

In many aircraft applications, Kanigen nickel alloy coating is proving the advantage of a hard, corrosion-resistant surface on aluminum. The uniformity of the coating permits full machining operations prior to coating with no subsequent clean up.

Machinery and equipment manufacturers use hard Kanigen nickel alloy coatings to control wear—and corrosion—on piston rods, printing press beds, ink cylinders, linkages, etc. Valve manufacturers control wear on seal rings with Kanigen nickel alloy. Pump impellers and casings give less erosion trouble when Kanigen nickel alloy coated. The coating has shown considerable promise in solving some troublesome cases of cavitation erosion—particularly in conjunction with aluminum alloys.

Kanigen nickel alloy coatings are not usually recommended for applications where two coated parts are expected to rub together without lubrication. Kanigen nickel alloy coating is recommended on many materials to reduce the galling tendency.

KANIGEN NICKEL ALLOY AS AN INTERMEDIATE OR BONDING COATING

A thin coating of Kanigen nickel alloy on aluminum permits excellent solder adhesion. Tin-lead solders wet the Kanigen nickel alloy coating readily if sufficient heat is provided—about 500°F (260°C). Dip tinning is very simple once the Kanigen nickel alloy coating is applied.

For decorative plating, a thin bonding coating of Kanigen nickel alloy may be applied to aluminum followed by bright nickel and chromium.

Kanigen nickel alloy coatings exhibit excellent "wettability" and "flowability" when deposited on high temperature alloys, such as austenitic stainless steels and Inconel, for use as pre-placed, elevated temperature brazing material. Complex assemblies may be fabricated by plating the components and furnace brazing at 1800°F in a dry hydrogen atmosphere. Satisfactory resistance to oxidation is displayed by the brazed joints after extended exposure to air at temperatures up to 1500°F.

SALVAGE

Because of its remarkable uniformity, Kanigen nickel alloy coating may be used to build-up uniformly worn or mismachined parts. For instance, a compressor shaft machined 0.002 in. undersize on the diameter may be coated to a thickness of 0.001 in. bringing the diameter back to the nominal value. Usually no machining or grinding after coating is required. Similar procedures have been used on pump impellers and housings.

Recommended maximum thickness

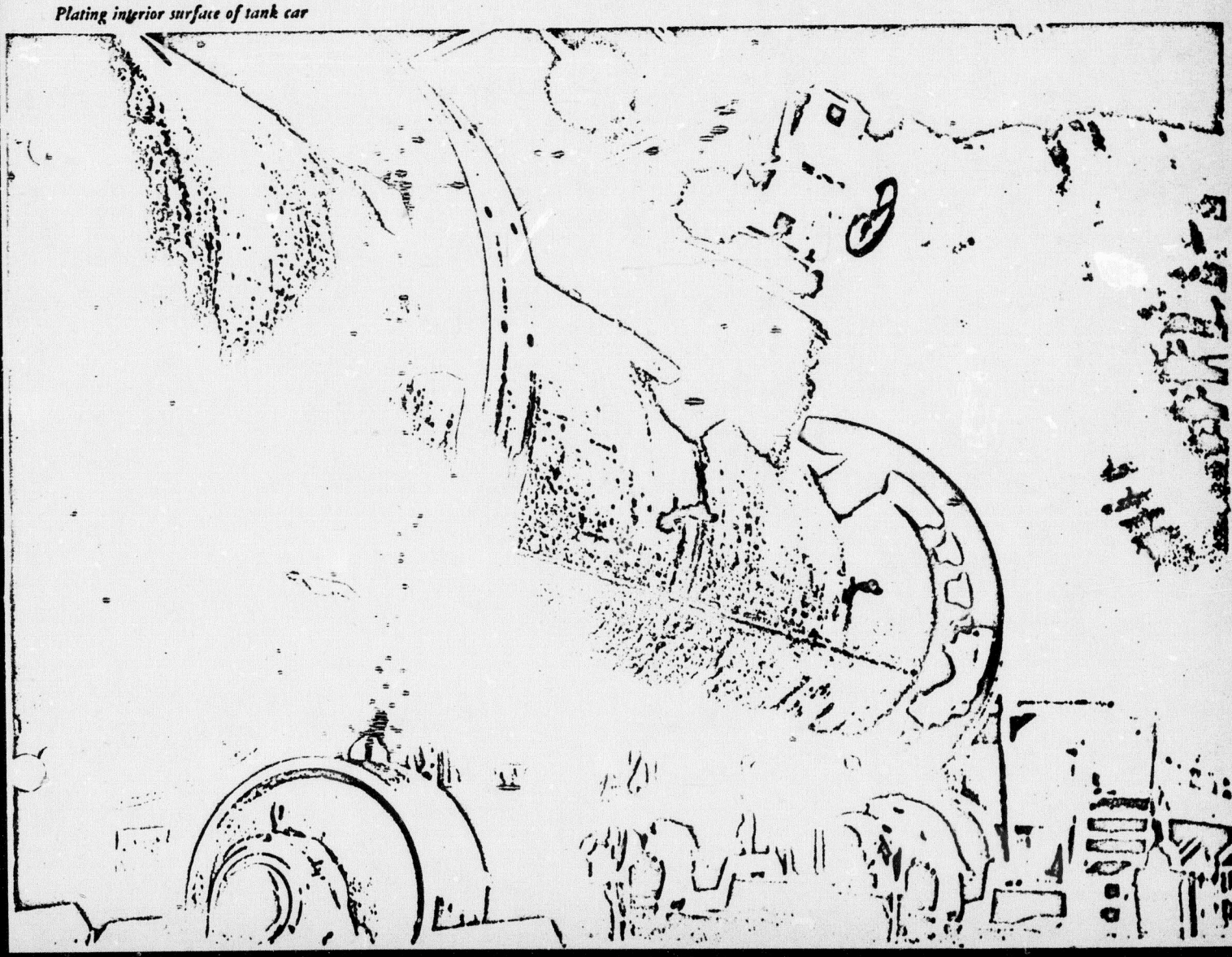
A maximum build-up of more than 5.0 mils (0.005 in.) is not normally recommended from a cost standpoint. While greater thicknesses are possible, the cost advantage through the elimination of machining after coating may be nullified where very heavy thicknesses are employed.

Industries now being served with Kanigen chemical nickel alloy coating

Appliance
Atomic Energy
Automobile
Aviation
Baking
Chemicals
Communications
Electrical Equipment
Electronics
Instruments
Machine Tools
Materials Handling Equipment
Medical Instruments
Mining
Missile
Ordnance
Paper
Petrochemical
Petroleum
Plastics
Printing
Chemical Equipment
Railroad
Screw Machine Products

00652

Plating interior surface of tank car



How to get the most out of Kanigen coating on your parts

TYPE OF SERVICE

In general, Kanigen nickel alloy coatings are useful where iron contamination, wear and neutral or alkaline corrosion is a problem. The sections on physical characteristics and applications give detailed information on the properties of the coating. (Since all applications could not be covered, write General American about your specific problem.)

GAS ENTRAPMENT

Kanigen nickel alloy coating is applied by immersing the part in a tank of plating solution or by pumping the solution through the interior of large parts. Since hydrogen gas is evolved during the process, care must be taken to prevent gas entrapment. The design of parts should be checked to eliminate gas trapping pockets. If such pockets exist, they should be vented, or the design should be altered. In some cases, such as circular vessels with adequate axial openings, it is possible to rotate the part during coating... thereby eliminating entrapment problems.

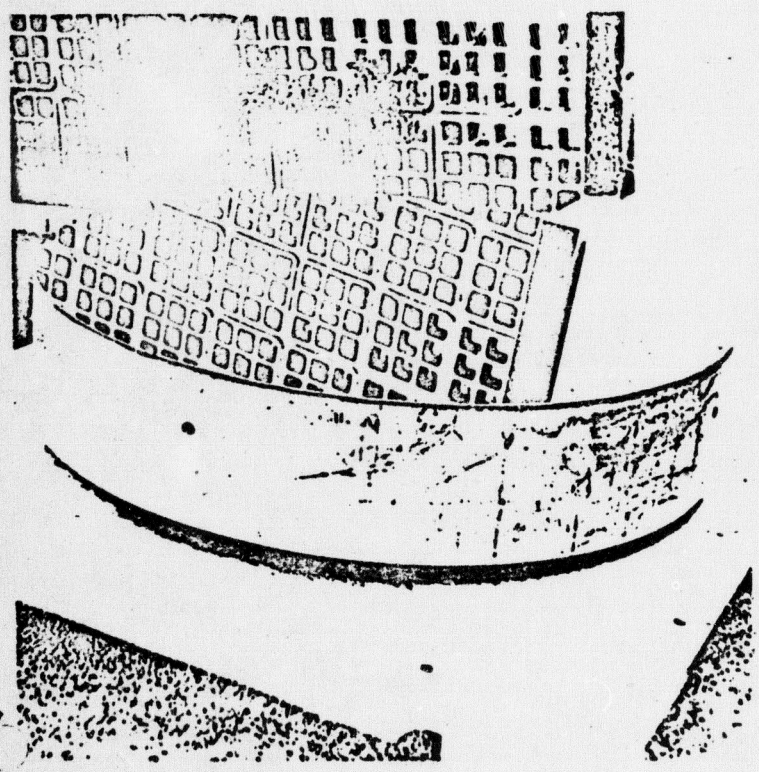
MASKING

While it is possible to mask areas where no coating is desired, it must be stressed that all the masking lacquers and tapes thus far utilized are less than perfect in "stopping-off" plating. The 205°F temperature involved in Kanigen chemical nickel alloy plating causes at least minor or partial breakdown of tapes and lacquers. Masking thus frequently is troublesome and expensive. Mechanical devices, such as plugs and caps, perform satisfactorily when they can be used. Because the Kanigen nickel alloy coating is so uniform, it usually is possible to make allowance for the coating thickness in the part design. No machining or clean up is required in most cases after coating. If the coating thickness is less than 1.5 mils (0.0015") it usually costs less to plate the parts all over. For thicker coatings, it may be desirable to consider masking, especially if large uncoated areas can be tolerated.

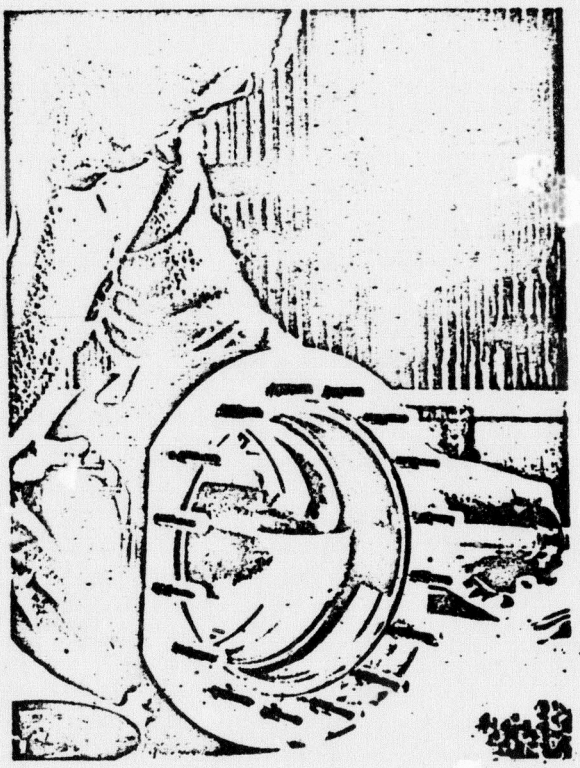
RACKING

Except for small parts which can be coated *en masse* in a plating barrel, it is necessary to hang the parts on a wire or a rack during coating. As a result, some provisions must be made to hold the part by an un-

Primary mirror for solar telescope—Kanigen nickel coated



Kanigen nickel coated butterfly valve



00653

critical area. Usually, a part held on a wire will plate under the wire without a mark to a thickness of about 2.0 mils (0.002 in.). If the part is very heavy, the full thickness of coating may not be obtained under the supporting wires where coating thickness is over 0.002 in. Part design should take into consideration the means for racking.

CLEANING

As with any coating or plating operation, it is necessary to have an absolutely clean surface prior to coating. Cleaning solutions adequately remove light grease films, light dirt and oxides. They will not remove—with standard procedures—weld scale or flux, weld spatter, paint, heavy grease, or heavy mill scale.

Grinding, blasting or chemical descaling procedures may be used prior to the standard cleaning operations to prepare a part for coating. Sand blasting must be used carefully, as it usually leaves a rough surface with pits, overhangs and sand inclusions. Where sand blasting is required, it is felt that the coating thickness should be a minimum of 2.0 mils (0.002 in.).

Polished parts may be satisfactorily shipped with a light oil coating or a coating soluble in trichlorethylene. Where surface finish or dimensional tolerances are not critical, it is best to ship parts without any protective coating. Any light rusting which occurs will be removed readily in the cleaning process.

Quotations normally specify that all parts to be coated be cleanable by ordinary methods. Parts should be free of paint, scale or special protective coatings and free from lead, zinc, tin, or cadmium contamination.

PACKAGING

Coated parts are normally returned packed in the same manner as received. It is desirable to ship parts in re-usable containers or packages which will give adequate protection to the coated parts. Wooden boxes or crates provide excellent protection and can usually be used for several shipments. 250 lb. test cardboard containers are normally adequate for one round trip. Of course, very light or small parts can be handled satisfactorily in bulk. Many industrial parts can be handled in bulk where surface finish is not a major concern.

Plating methods used

BARREL COATING

Many small parts that cannot normally be handled by electroplaters in this manner, can be coated "en masse" with Kanigen nickel alloy. Since there are no problems of electrical contact or of excessive currents, it is possible to operate the barrels at a much lower rate of speed than is normal in electroplating. Many parts damaged by tumbling at high speed can withstand the low speed tumbling in the Kanigen process. The thickness of coating has the same uniformity as when done on a rack.

COATING BY RACKING

By far the largest share of parts are coated on racks. The part is hung on a rack and immersed in a tank of Kanigen solution. The part is coated wherever solution touches the part.

JIG COATING

Many large hollow parts require coating on interior surfaces only. It is possible to coat such parts—particularly vessels—by pumping solution through the piece. A jig may be set up to accomplish this purpose readily. General American's Sharon, Pennsylvania plant, the largest chemical nickel alloy plating facility in the world, regularly processes railroad tank cars and other steel vessels of like size.

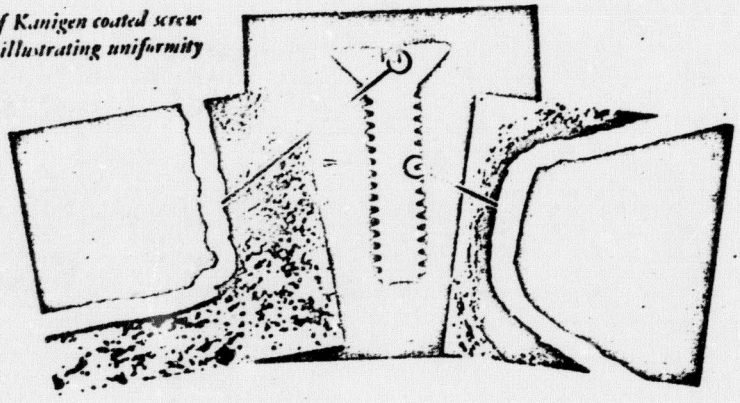
How to obtain Kanigen chemical nickel alloy coating

With the development and perfection of the Kanigen process, General American has granted licenses to perform this service throughout much of the world. The licensees, in addition to General American, are equipped to process parts by the above listed methods. Your requirements for Kanigen chemical nickel plating can be handled by contacting General American or the licensee most convenient to you.

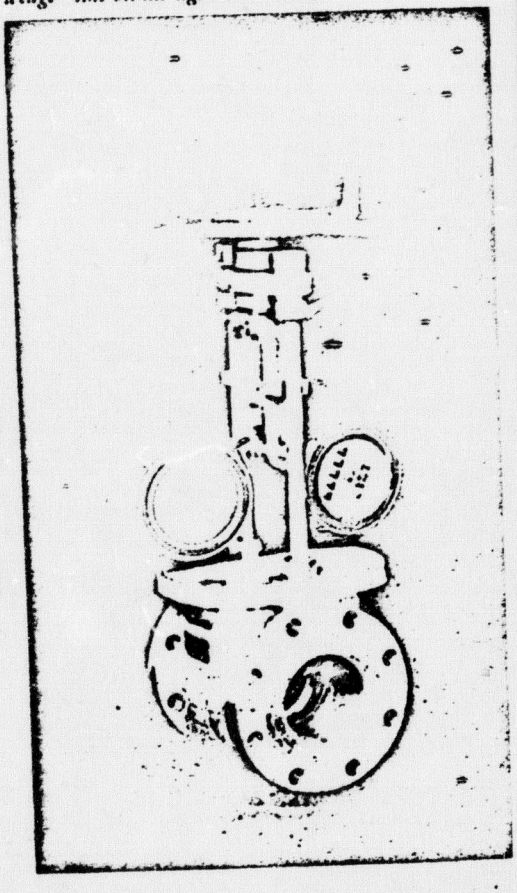
General American and its licensees share the benefits of each other's research and development in this important coating method. Therefore, all Kanigen plants have the latest and best techniques and processes for application of highest quality Kanigen nickel alloy coating.

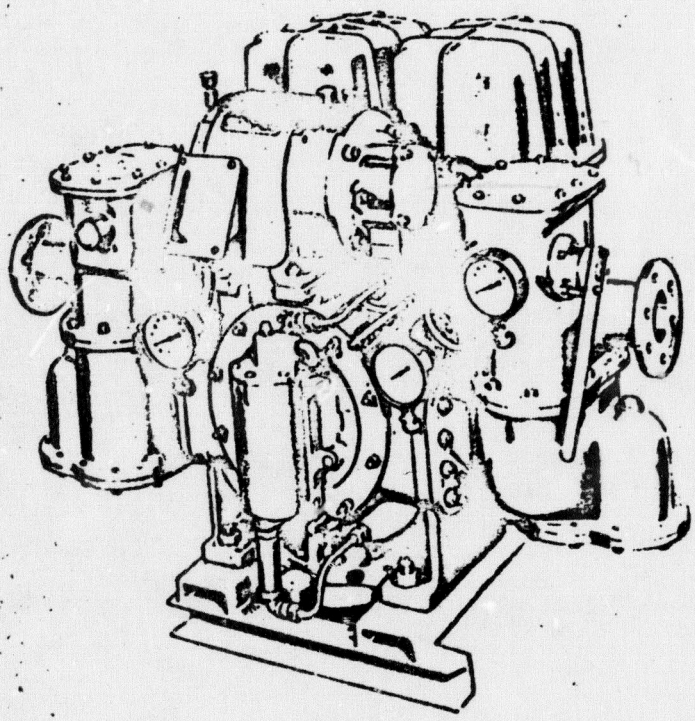
General American's Research Laboratory has a large force of scientists engaged in developing new fields of application for Kanigen nickel alloy coatings. They constantly seek improvement in the process to better meet your requirements for corrosion resistance, contamination protection and wear resistance.

photomicrograph of Kanigen coated screw thread and groove illustrating uniformity of deposit



Kanigen coating protects Hamer "visible wedge" line blinds against corrosion





Kanigen coating of Blackmer pumping units helps eliminate rust from jet fuel systems

reduced. Within an error of about 5–10 per cent, OELSEN's results are generally reliable. In the case of $FeAl_3$ there is good agreement with a heat of formation determined by BILTZ and HAASE [28] from heats of solution in dilute hydrochloric acid. The heats of formation of CoAl and Co_2Al_5 obtained in the same manner by BILTZ and

Solid:

N_{Al}	Fe		Co		Ni	
	ΔH_{293}	ΔV_{293}	ΔH_{293}	ΔV_{293}	ΔH_{293}	ΔV_{293}
0·05	− 700	− 0·008			− 1,900	− 0·02
0·10	− 1,450	− 0·02			− 3,700	− 0·039
0·20	− 2,800	− 0·052				
0·25	− 3,400	− 0·081			− 9,400	
0·40	− 5,000		− 10,300		− 14,000	− 0·098
0·45	− 5,600		− 11,800		− 15,600	− 0·117
0·50	− 6,000		− 13,200	− 0·15	− 17,000	− 0·127
0·667	− 6,500				− 12,600	
0·715	− 6,800		− 10,000	− 0·04		
0·75	− 6,650	− 0·02			− 9,500	
0·82			− 7,200			
Accuracy	± 400		± 700		± 800	

HOLVERSCHEIT [41], are however, 2·5 kcal/g-atom more negative than those of OELSEN, whose results have been preferred here. Heats of formation of Fe-Al alloys were recently re-determined by KUBASCHEWSKI and DENCH [252] who used a direct method. The agreement with OELSEN's values was very good when these were corrected for the impurities present in OELSEN's iron.

The distribution of Al between {Ag} and {Fe} was studied by CHIPMAN [77] and CHIPMAN and FLORIDIS [79a] at 1600°C. From the results and the approximately known activities of Al in {Ag}, the relation

$$RT \ln \gamma_{Al} = -12{,}950 + 22{,}250\, N_{Al} \quad (1600°C)$$

was obtained for solutions containing up to 25 atomic-per cent Al.

X-ray and pyknometric densities have been obtained by various observers [472, 56, 25], but the volume changes given above may still be subject to appreciable alterations.

Attention may be drawn to a study of the electron-density distribution in the compound NiAl by AGEEV and GUSEVA [1]. The electron density is highest (0·9) along bridges formed between Ni

Faramiter shield

M-D577A

Use 2 7/8" Bond Specmen Set up for 6" Distance
3 Passes @ 1/4" steps @ 70% = .015" thick
17.5 ft./min. Gun Traverse

TECHNICIAN 1466
SHEET 1 OF 1
DATE 11/12/73
W.O.# 394
Project No.

13/14 NV 73

11/13/73

00629

LAB SERVICES

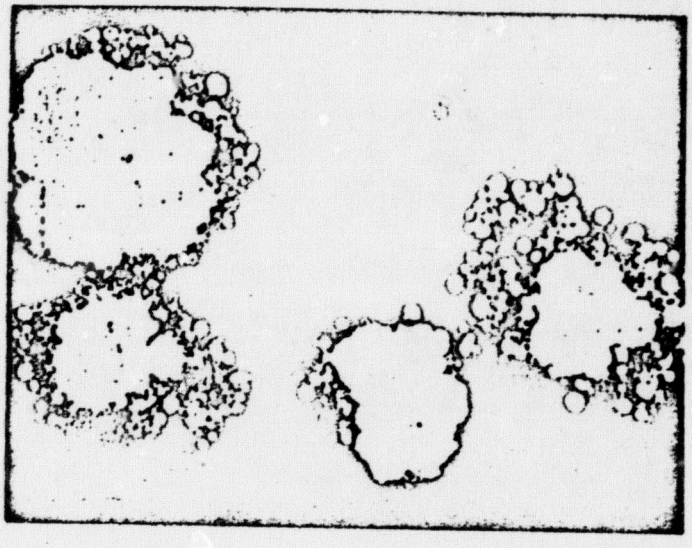
ThermoSpray Evaluation Data Sheet

Material	Nozzle	Meter Valve	Pressures Oxy	Pressures Fuel	Pressures Air	Flows Oxy	Flows Fuel	Clicks	Carrier (1)	PSA PSI	PSA Inter-sect.	Spray Dist.	Cool or Pinch.	Spray Rate	D.E.	Comment
450	P7-G	12	18	13	/	30	36	7	O2	/	/	6"	/	6.5#	/	
Metco 2790	"	"	"	"	/	"	"	7	"	/	/	6"	/	6.7#	/	
Superbond	"	"	"	"	/	"	"	7	"	/	/	6"	/	6.1#	/	

DX
KC

167

E 167-1



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E. Comment

DX
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167

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DEFENDANT'S EXHIBIT
KN
NO.

Lot # 4476 Rec'd 11/15/73 LAB SERVICES REPORT (1) WORK ORDER 394 DATE 11/13/73

EQUIPMENT STP Gun 11/13/73 TENSILE TEST PROJECT — TECH. [illegible]

BASE MATERIAL	SPECIMEN No.	SURFACE PREPARATION	BOND COAT	OVERCOAT	O/ACM PREHEAT	SPRAY DISTANCE	FIN. COATING	OUTSIDE DIA.	AREA IN²	LOAD LB.	TENSILE P.S.I.	COMMENTS
S	1	Grit with	.015" @	None	200°F	6"	.015"	.997"	.781	3770	4830	All spraying done with
S	2	Al_2O_3	.005" per	"	"	6"	"	.998"	.782	4020	5140	Automatic work handling
S	3	60 Grit wheel	PASS	"	"	6"	"	.997"	.781	4030	5160	Equipment

E 168

00330

Exotec 29904 Lot #556 RAW 11/13/73

LAB SERVICES REPORT (2) WORK ORDER 394 DATE 11/13/73

EQUIPMENT 5P Gun 11/15/73 TENSILE TEST PROJECT — TECH. 1465

BASE MATERIAL	SPECIMEN NO.	SURFACE PREPARATION	BOND COAT	OVERCOAT	QUICK PREHEAT	SPRAY DISTANCE	FIN. COATING	OUTSIDE DIA.	AREA IN²	LOAD LB.	TENSILE PSI.	COMMENTS
S	4	Grind with	.015"	None	200°F	6"	.015"	.978"	.782	4080	5220	All spraying done with
S	5	AL_2O_3	@ .005"	"	"	6"	"	.997"	.781	3840	4930	Automatic work Handling
S	6	White Grit	Per Bess	"	"	6"	"	.976"	.779	3960	5080	Equipment "
		Wheel										

E 169

00631

DS=9

Kuiperbond LOT # 744 RCVD 11/13/73 AKT 13/1/0573 LAB SERVICES REPORT (3) WORK ORDER 384 DATE 11/13/73

EQUIPMENT STP Grind TENSILE TEST PROJECT — TECH. [illegible]

BASE MATERIAL	SPECIMEN No.	SURFACE PREPARATION	BOND COAT	OVERCOAT	OVEN PREHEAT	SPRAY DISTANCE	FIN. COATING	OUTSIDE DIA.	AREA IN²	LOAD LB.	TENSILE P.S.I.	COMMENTS
25	7	Grind with	.015"	None	200°F	6"	.015"	.998"	.782	2740	3500	All spraying done on Automatic Powder Handling Equipment
25	8	Al_2O_3 Grit @	.005"	"	200°F	6"	"	.998"	.782	3040	3880	
25	9	Wheel	Per Pass	"	200°F	6"	"	.998"	.782	2930	3750	

E 170

00632

D5-9

Conap Epoxy RAW 11/13/73 LAB SERVICES REPORT (4)

WORK ORDER 394 DATE 11/13/73

EQUIPMENT Lot# 0131B (Base) Lot# 0322B (Hardner) TENSILE TEST PROJECT _____ TEAM 14 & 15

	BASE MATERIAL	SPECIMEN No.	SURFACE PREPARATION	BOND COAT	OVERCOAT	PREHEAT	SPRAY DISTANCE	FIN. COATING	OUTSIDE DIA.	AREA IN²	LOAD LB.	TENSILE P.S.I.	COMMENTS
RS	Glue	Machine Finish	—	—	—	—	→	.999"	.7??	7770	9900		

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E 172

STATUS REPORT

Project 301, Dr. H. S. Ingham, Jr.

7 November 1973

OBJECTIVE:

Determine additive constituent to Eutectic's "Xuperbond" powder.

SUMMARY:

1. Metallographic analysis (for example report by R. J. DuMola 17 January 1973) of Xuperbond powder showed a nickel core and aluminum cladding both very similar to those of METCO 450. In addition, there were foreign particles mixed with the aluminum cladding, sensitive to polarized light indicating a ceramic. The following was aimed to separate the various constituents of the claddings.

2. Preliminary tests were made with various solvents to find one that would attack the powder: cold water, hot water, acetone, alcohol, "METCO APT" (thinner for phenolic resin), and methyl pyrrolidone. Only the latter (M-P) showed any visible effect.

3. 100 grams of Xuperbond (Lot #465) was mixed with 200 ml. of methyl pyrrolidone. When decanted off, the M-P was a greenish suspension (designated "C") with light colored particles that appeared to have been some of the cladding powder.

4. The remaining powder, i.e., the bulk of the original 100 grams, was washed with acetone to remove the M-P; this did not appear to otherwise affect the powder.

5. This powder was then mixed with about 200 ml. of 20% sodium hydroxide solution which reacted, presumably dissolving aluminum. When the reaction was completed, the liquid was decanted off and this appeared to contain a fine powder suspended. (There was no such suspended powder when METCO 450 was similarly treated with sodium hydroxide solution.) This suspension was dried in a pan leaving less than about a gram of a fine powder (designated "B").

6. The remaining powder appeared to be the core-nickel mixed with foreign particles. This was spread on a sheet of paper and separated into two components by moving a magnet underneath the paper. The non-magnetic portion (a fraction of a gram) was a light colored powder (designated "A").

7. Assuming the remaining magnetic powder was essentially core-nickel, the other separated portions were sent to Lucius Pitkin, Inc., for spectrographic analysis. There were the two powders "A" and "B", and the M-P suspension "C". Results were reported by Pitkin, 2 November 1973 (Report No. M-2937).

Cont'd/.....

DEFENDANT'S EXHIBIT KT NO.

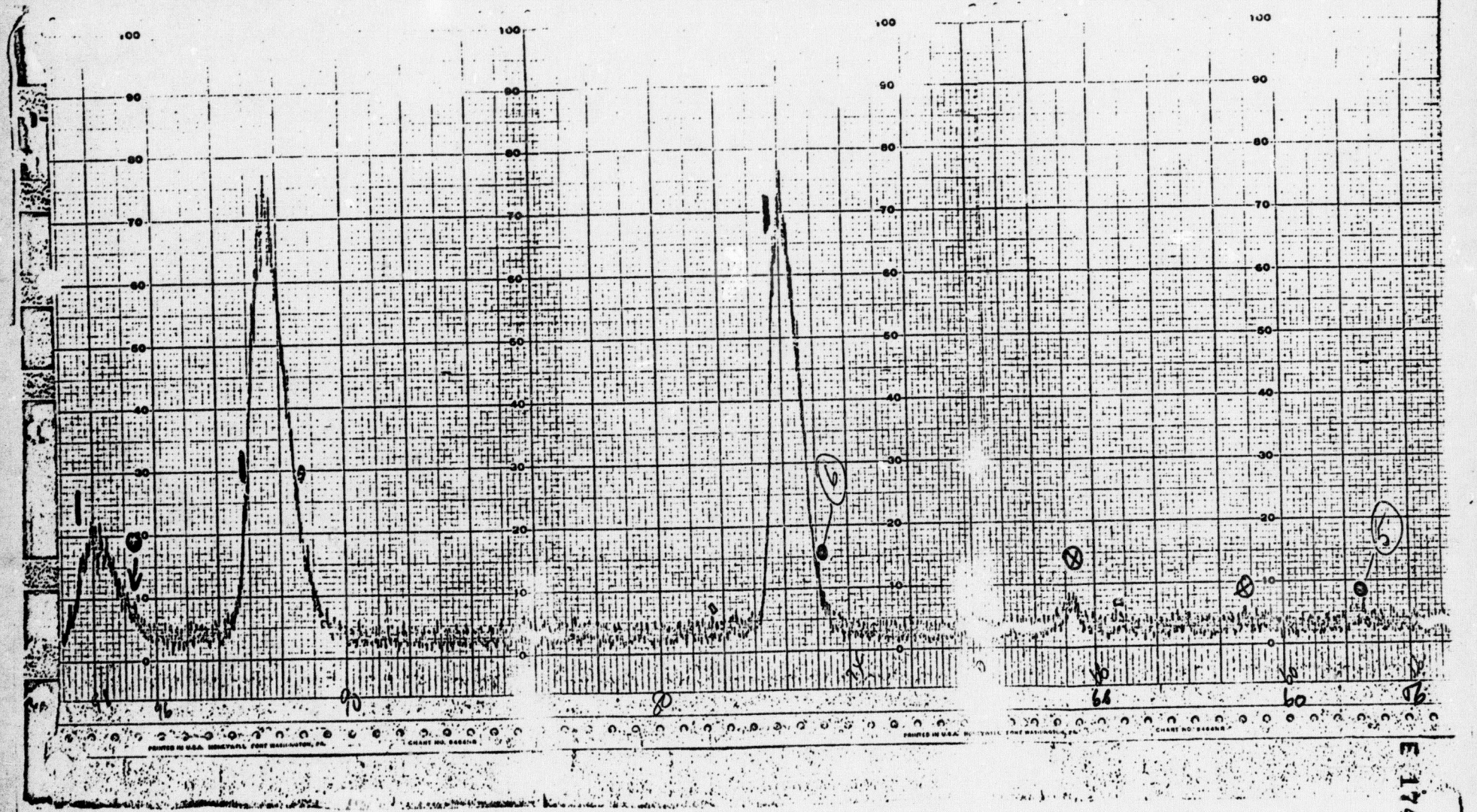
8. Major constituents of "A" were lead, chromium and nickel. Major constituents of "B" were lead and chromium. The nickel in "A" (and minor portions of nickel in "B") are presumed to be from the core. Similarly, minor portions of aluminum in both samples are presumed to be from the cladding. Thus, "A" and "B" apparently are fine and coarse size fractions of the same ceramic constituent in the cladding. Thus, it is deduced to be lead chromate, which handbooks indicate to be yellow crystals. (Other lead chromates are red, which this constituent is not. The powder does not appear to be separate constituents of lead and chromium oxides mixed, since chromium oxide is dark colored. Glass is excluded since silicon content is low.)

9. Nothing is concluded regarding the chemistry of suspension "C".

10. About a pound of clad powder was made similarly to METCO 450 except with the addition of 1% of lead chromate powder. The clad powder gained a greenish appearance very much like Xuperbond.

HSIJr:mgc

Distribution:
File: D301:43
H. S. Ingham, Jr.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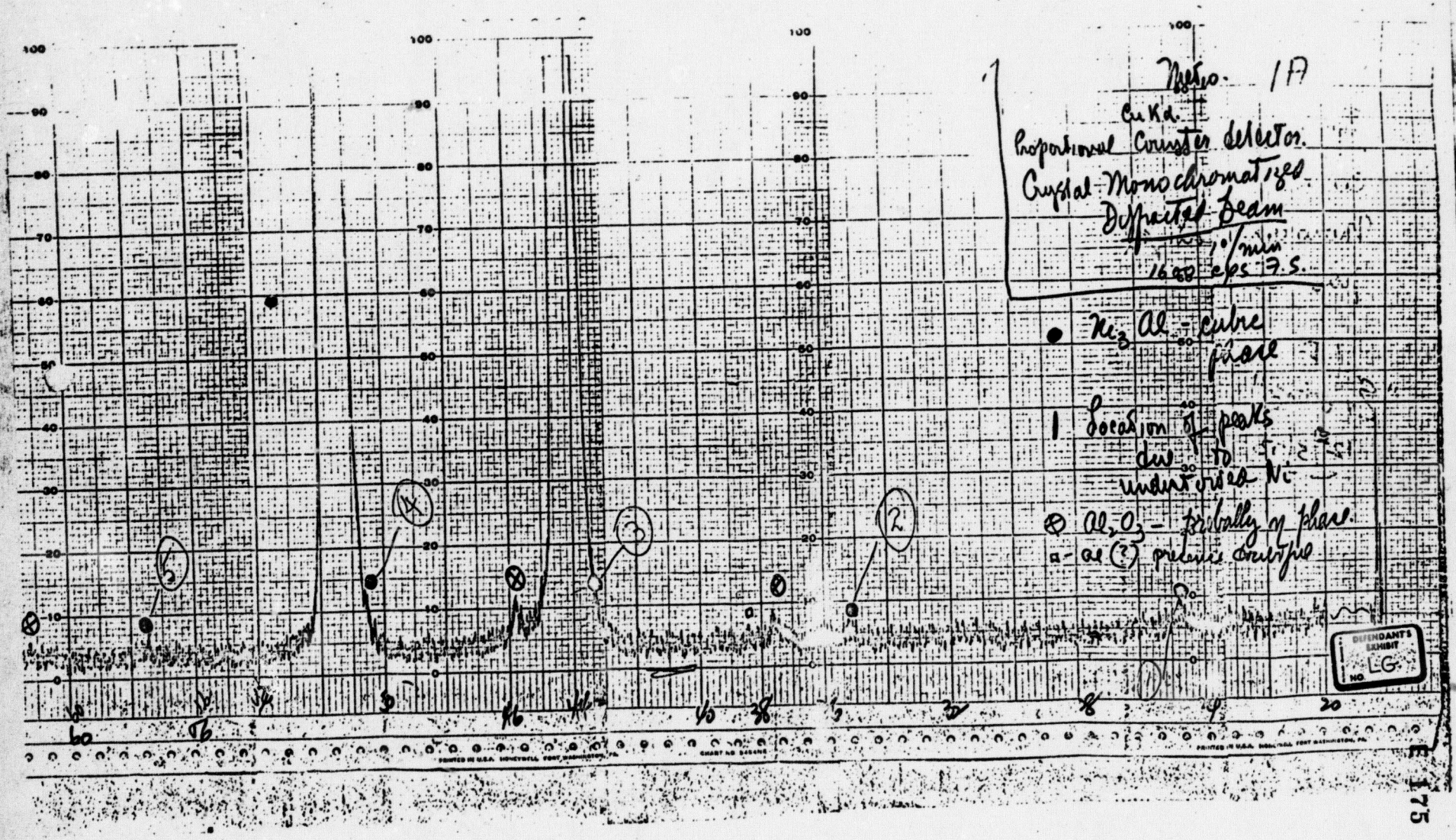
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⊗ Al_2O_3 - probably η phase
α - Al (?) present as overlap
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ABANDONED

E 176

SERIAL NO. (Series of 1960) 72543	P. R. Div.		PATENT NUMBER
Assistant examiner Wheeless	Class 117	Subclass 105	DATED
Division No. 25	Filed complete (Date) NOV. 22, 1960	Serial No. 72 543	CLAIMS FOREIGN PRIORITY: Country / Date

Applicant(s)

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SHEPARD, ARTHUR P. OF FLUSHING, N. Y.

Number claims allowed	Print claim(s)	Class	Subclass

Assignor to

Title of invention

FLAME SPRAYING SYNERGISTIC COMPOSITES

☐ Division of ☐ Continuation of ☐ Substitute for abandoned — APPLICATION Serial No. / Filed / Now Patent No. / Granted

☐ Continuation-in-part of — APPLICATION Serial No. / Filed

Sh. drw.	Ex. claims	Filing fee	Transaction	Atty's docket
1	42	$72	62191	METCO 305

Drwg. transferred to S. N. 125,[illegible] Aug. 16, 1961

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PARTS OF APPLICATION FILED SEPARATELY

PREPARED FOR ISSUE

(Assistant Examiner) (Docket Clerk)

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(Primary Examiner) (Division)

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E 177 60-4

72543

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233 BROADWAY
NEW YORK 7, N. Y.

Date: Nov. 21, 1960

Hon. Commissioner of Patents
Washington 25, D. C.

ON ALL PAPERS PLEASE
FURNISH OUR FILE NO.

Dear Sir:

Re the application of Ferdinand J. Dittrich and Arthur P. Shepard

for Plame Spraying Synergistic Composites

we enclose

(x) Specification

(x) Oath, Power of Attorney and Petition

(x) 1 Sheet(s) Drawings

(x) 42 Claim(s) in excess of 20

(x) $72 .00 filing fee (covered by enclosed check)

( ) Assignment

( ) $3.00 recording fee (covered by enclosed check)

( ) Priority is hereby claimed on the basis of the following:

Country	Serial No.	Date

Respectfully,

BURGESS, DINKLAGE & SPRUNG

BY Arnold Sprung

E 177-P

DEC-1 60 62191 A-CX—121 Metco30S 30.00

DEC-1 60 62192 A-CX—122S:as 42.00

FLAME SPRAYING SYNERGISTIC COMPOSITES

72543

This invention relates to the flame spraying of synergistic composites. The invention more particularly relates to the flame spraying of synergistically-clad flame spray powders, to a novel group of flame spray materials comprising such synergistically-clad flame spray powders, and more broadly to the spraying of other synergistic composites wherein the synergistic action involves the generation of heat.

Flame spraying involves the feeding of a heat-fusible material into a heating zone, wherein the same is melted or at least heat-softened and then propelled from the heating zone in a finely divided form, generally onto a surface to be coated.

The material being sprayed is generally fed into the heating zone in the form of either a powder or a wire (the latter term designating both rods and wires). The spraying is effected in a device known as a heat-fusible material spray gun or a flame spray gun.

In the wire type flame spray gun the rod or wire of the material to be sprayed is fed into the heating zone formed by a flame of some type, where it is melted or at least heat-softened and atomized, usually by blast gas, and thence propelled in finely divided form onto the surface to be coated. The rod or wire may be a conventionally formed rod or wire of a metal, or may be formed by

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sintering together finely divided material or by bonding together finely divided material by means of a plastic binder or other suitable binder which disintegrates in the heat of the heating zone, thereby releasing the material to be sprayed in finely divided form.

For spraying finely divided, i.e., powdered material, a powder type flame spray gun is used in which the powder, usually entrained in a carrier gas, is fed into the heating zone of the gun formed by a flame of some type. The powder is either melted or at least the surface of the grains heat-softened in this zone, and the thus thermally conditioned particles propelled onto a surface to form a coating. In the powder type spray gun, as no "atomizing" energy is required, a separate blast gas is often dispensed with, though the same may be supplied in order to aid in accelerating the particles and propelling them toward the surface to be coated.

The blast gas may be provided for both the wire type and powder type guns to perform the additional function of cooling the workpiece and the coating being formed thereon.

The heat for the heating zone is most commonly produced from a flame caused by the combustion of a fuel, such as acetylene, propane, natural gas or the like, using oxygen or air as the oxidizing agent. The heat may, however, also be produced by an electrical arc flame or in the newer type of guns, by a plasma flame. The plasma

flame may in itself constitute part of an electric arc or, in accordance with a newer development, may be in the form of a "free plasma stream", i.e., a stream of plasma which may be considered independent of the arc as it does not contribute to the electric flow between electrodes.

Heat-fusible material spray guns utilizing electric resistance heating or induction heating as the heat source have also been proposed but have not proven commercially successful except in connection with the spraying of low melting point metals, such as solders, lead and zinc.

Flame spraying in the initial stages of its commercial development was used mostly for the spraying of various metals and was often referred to as metallizing. However, the art of flame spraying extends to the spraying of a much wider group of materials, including higher melting point or refractory metals, ceramics, cermets and the like, and such materials are of increasing commercial interest.

In the case of spraying heat-fusible materials in the initial form of a rod or wire, the rod or wire is generally of a single composition, i.e., in the form of a specific metal, alloy, ceramic or the like. While it is true that rods or wires formed from finely-divided material bound together with a binder of plastic or the

like, as mentioned above, were known, the binder did not take part in the spraying or contribute to the coating and merely served the purpose of maintaining the rod or wire in shape until fed into the heating zone.

In the case of flame spray powders, while powders formed of several constituents were known, the same were generally in the form of a powder mixture of the individual constituents or, at best, a particle aggregate.

One object of this invention is the spraying of the heat-fusible material in a novel form, which allows the obtaining of superior results.

A further object of this invention is a novel group of flame spraying materials.

These and still further objects will become apparent from the following description read in conjunction with the drawings in which:

Fig. 1 diagrammatically shows a cross-section of a grain of a novel flame spray powder in accordance with the invention;

Fig. 2 is a diagrammatic cross-section of a further embodiment of a grain of a novel flame spray powder in accordance with the invention;

Fig. 3 is a diagrammatic cross-section of an embodiment of a novel flame spray rod or wire in accordance with the invention; and

Fig. 4 shows an elevation of a further embodiment of a novel flame spray rod or wire in accordance with the invention.

In accordance with a broad aspect of the invention the flame spraying is effected with the material being sprayed in the form of a powder, the individual grains of which are in the form of a clad composite consisting of nuclei and at least one coating layer of a different material which will synergistically act with the nuclei in the process.

Each grain of the synergistically clad composite powders may also be in the form of a nucleus with two or more different coating layers which will synergistically act with each other and/or with the nucleus.

The synergistic action of the coating layer with the nucleus and the coating layers with each other, as the case may be, may manifest itself as a chemical or physical action or both, and may appear in the heating zone and/or along the path of travel to the surface to be coated, or at the sprayed coating as sprayed, or after a subsequent treatment such as a heating or fusing operation.

The synergistic action between the nuclei and/or the coating layer or layers may, for example, involve the physical or chemical generation of heat by exothermic reaction in the heating zone, along the path of travel to the target, or on the coated surface itself, so as to

increase the thermal efficiency of the process, aid in the bonding of the coating and/or produce results and effects by this *in situ* generated heat which cannot be achieved by the externally supplied heat. The synergism resulting in the exothermic reaction may be caused by the utilization of two components which will combine at the temperatures involved to form a material with a melting point higher than that of either of the constituents, with a considerable release of heat, by the use of components which will chemically combine in exothermic reaction, as for example where one acts as an oxidizing and the other a reducing agent, or by the use of components which will dissolve together in generation of heat or the like.

Thus, for example, one of the components may be a nickel-containing component and the other an aluminum-containing component which will combine under the spraying conditions to form a nickel-aluminum inter-metallic compound with an exothermic reaction. Similarly, one of the components may contain the aluminum and the other antimony, calcium, cobalt, lanthanum, lithium, manganese, nickel, palladium, praseodymium, dysprosium, or a combination thereof which, upon combining during the spraying, form a higher melting point compound with the generation of heat. Similarly the clad-composite powder may be a combination of nickel with elemental phosphorus, silver, copper, aluminum or the like, which will combine in exothermic reaction.

The synergistic action may also involve a protective effect of the coating material on the nuclei or a lower coating layer in order to prevent loss or destruction of this under-material and allow the spraying of the combination. Thus, for example, nickel may be coated on nickel-phosphorus, nickel-boron, or the like in order to prevent loss or destruction of the fluxing agent and allow the formation of a self-fluxing coating, as for example in the "spray-weld process."

The synergism may also involve a bonding effect in order to allow a satisfactory bonding on a base of sprayed materials which normally present bonding difficulties, as for example the synergism of a matrix metal, such as nickel or cobalt, with a hard or refractory material, such as tungsten carbide, Al_2O_3, diamonds or other hard gems or the like.

Bonding to the base or substrate being coated may also be aided by the synergistic action of exothermic reaction, as for example in the case of nickel-coated aluminum powder.

The synergistic effect may also involve the combining of the components to form a third component, such as a compound or alloy or inter-metallic compound desired as the coating constituent. This may involve a dissolving together of the components, alloying the components, or a chemical reaction between components which may be endothermic in nature if sufficient heat is available for the process.

The powder particles may be in the form of a nucleus with a single coating layer, or may be in the form of a nucleus with a multiple number of layers of the same or different materials.

The clad powders in accordance with the invention may be formed in any known or desired manner and preferably by the known chemical plating processes in which a coating material is deposited on a seed or nucleus of another material, or in which multiple layers of various materials are built up on the seed material, or in which various materials are co-deposited in a single layer on the seed material.

A preferred mode of forming the clad powders involves the depositing of a metal from a solution by reduction on a seed or nucleus, such as the hydrogen reduction of ammoniacal solutions of nickel and ammonium sulphate on a seed powder catalyzed by the addition of anthraquinone. It is also possible to form the coating by the use of other known coating processes, such as coating by vapor deposition, by the thermal decomposition of metal carbonyls, by hydrogen reduction of metal halide vapors, by thermal decomposition of halides, hydrides, carbonyls, organo-metals or other volatile compounds, or by displacement gas plating and the like.

The clad powders for this invention should have the general over-all shape and size of conventional, flame-spray powders, and thus for example should have a

size between -60 mesh and +3 microns and preferably -140 and +10 microns (U.S. Standard screen mesh size). Most preferably the powder should be as uniform as possible in grain size, with the individual grains not varying by more than 250 microns and preferably 75 microns.

Depending on the particular flame spray process and the desired purpose, the clad powders may be sprayed per se or in combination with other different clad powders, or in combination with other conventional flame spray powders or powder components.

Fig. 1 diagrammatically shows an embodiment of a clad powder having a nucleus of aluminum and a coating of nickel.

Fig. 2 shows a multi-layer powder of nickel and copper on nickel-boron.

While the powders are preferably sprayed, as such, in a powder-type of flame spray gun, it is also possible to combine the same in the form of a wire or rod, using a plastic or similar binder which decomposes in the heating zone of the gun, or, in certain cases the powders may be compacted and/or sintered together in the form of a rod or wire.

In the limited case where the synergistic action of the components involves an exothermic reaction as, for example, the combination of nickel and aluminum to form the nickel-aluminum inter-metallic compounds, the

spray material may assume a form other than the clad powder and may, for example, be in the form of a suitable aggregate or a composite wire, such as a wire having a coating sheath of one material, such as nickel, with a core of the other material, such as aluminum, as shown in Fig. 3, or wire formed by twisting together and rolling separate wires of components, such as nickel and aluminum, as shown in Fig. 4. Various combinations of other exothermically-reacting components may of course be used in the formation of such wire, which exothermic reaction will substantially contribute to the heat economy of the flame spraying and may even show self-ignition characteristics when fed through the spray gun.

The following examples are given by way of illustration and not limitation:

EXAMPLE 1

An aluminum powder having a particle size between -140 mesh and +325 mesh (U.S. Standard screen size) is coated with nickel in the known manner by the hydrogen reduction of an ammoniacal solution of nickel and ammonium sulphate, using anthraquinone as the coating catalyst. The reduction is effected at a temperature between about 300 and 350° F. in a mechanically agitated autoclave using solutions containing 40-50 grams per liter of nickel and 10-400 grams per liter of $(NH_4)_2SO_4$ and 20-30 grams

per liter of NH_3. About .2 gram per liter of anthraquinone is used as the catalyst and the autoclave is pressurized with hydrogen at a pressure of about 300 lbs. p.s.i.g. After the nickel solution is depleted and the aluminum coated with an initial coating of nickel, the solution is discharged from the autoclave and replenished with a fresh solution which need not contain further amounts of the anthraquinone coating catalyst, as the initially formed nickel coating in itself acts as a catalyst. The cycle is continuously repeated until a composite powder is formed containing about 16 to 18% by weight aluminum and 84 to 82% by weight of nickel, and a size of -100 to +270 mesh.

The powder thus formed is flame-sprayed on a mild steel plate which has been surface-cleaned with emery cloth. The spraying is effected at about 7 inches from the plate, using a powder-type flame-spray gun as described in U. S. Patent 2,961,335, issuing November 22, 1960 and sold by Metco Inc. of Westbury, Long Island, under the trade name of "Thermospray" powder gun. The spraying is effected at a rate of 6 to 9 lbs. of powder per hour, using acetylene gas as the fuel at a pressure of 10 p.s.i. and a flow rate of 17 to 25 cu.ft./hr.

and oxygen as the oxidizing gas at a pressure of 12 p.s.i. and a flow rate of 29 to 35 cu.ft./hr.

The nickel coating and the aluminum base combine in the heat of the flame with a strong exothermic action, forming a nickel aluminum inter-metallic compound which deposits on the base as a dense, high quality coating which exhibits self-bonding characteristics. A coating layer of .002" - .004" thickness is built up in this manner. The coating may be used as a base material for spraying of further layers of different metals or the like and serves as an excellent intermediate bonding layer.

The coating layer may also be built up to a greater thickness as, for example, .004" - .008", for use as an oxygen barrier undercoat, or to even greater thickness as, for example, .020" - .040" or thicker as a wear-resistant - oxidation-resistant surface.

Due to its self-bonding characteristics the sprayed coating will adhere to a base without the conventional surface preparation or roughening, and due to the natural characteristics of a sprayed material, will allow further materials to be sprayed thereon with good bonding. The coating formed from the

powder has excellent oxidation-resistant characteristics even at high temperatures and in oxidizing atmospheres, and will for example eliminate the oxidation of base materials, such as molybdenum or the like. The sprayed coatings may be used as a lining in metal-melting crucibles or molten metal-handling equipment, and will not be wetted or penetrated by many molten metals, including self-fluxing alloys. Coatings formed of the sprayed material also show good potential as high temperature, wear-resistant coatings.

When the example is repeated on a molybdenum rod of 3/16" diameter, with a coating between .008" - .010" thick, the coated rod may be repeatedly heated to approximately 2000° F. in air, with a welding torch, and cooled to room temperature with no visible oxidation occurring.

Similar results may also be obtained if the composite powder contains 10 - 45% by weight of aluminum and 55 - 90% by weight of nickel.

EXAMPLE 2

Example 1 is repeated with the spraying being effected in turn on the following bases and prepared in the following manner:

Low alloy steels and stainless steels, smooth-ground to remove surface contamination; copper and copper base alloys, rough-ground or light-grit-blasted; aluminum and aluminum base alloys, rough-ground or light-grit-blasted; magnesium, rough ground or light-grit-blasted; and titanium, rough-ground or light-grit-blasted.

In each case when a further material, such as steel, alumina or the like, was sprayed over the coating in the conventional and well known manner, the same was bonded with a tenacious bond, though if this material had been initially sprayed on the surface as prepared in the manner indicated above, a satisfactory bond would not be obtained.

EXAMPLE 3

The nickel-clad powder of Example 1 is mixed with an Al_2O_3 powder having a particle size between 62 microns and 10 microns, in the ratio of about 40% of the nickel-clad powder with 60% by weight of the ceramic. The powder is sprayed, using the gun described in Example 1, on a mild steel plate which has been surface-cleaned by smooth grinding. Spraying is effected at a distance of about 7" from the plate at a rate of about 4 to 8

lbs. of powder per hr., using acetylene at a pressure of 10 lbs. p.s.i. and a flow rate of 17 - 25 cu.ft./hr., and oxygen at a pressure of 12 p.s.i. and a flow rate of 29 - 35 cu.ft./hr.

A self-bonding cermet coating is formed which showed excellent thermal shock-resistance, hardness, abrasion-resistance, and which strongly inhibited oxidation of the base.

It is possible to vary the percentages of the ceramic in the mixture between 5 and 85% in order to vary the properties of the coating. With an increased amount of the inter-metallic compound in the cermet coating formed, the bonding and thermal shock-resistant properties increased, whereas with an increased amount of the ceramic the hardness and wear-resistant properties of the coating are increased and the thermal conductivity decreased.

EXAMPLE 4

Example 3 is repeated, using the following materials in place of the aluminum oxide:

Zirconia, calcium zirconate, magnesium

zirconate, spinel, ceric oxide, hafnium oxide, rare earth oxides, molybdenum disilicide, tungsten silicide, chromium silicide, titanium silicide, tungsten carbide, titanium carbide and chromium carbide.

In each case an excellent coating was formed.

EXAMPLE 5

A nickel-phosphorus powder having a size between 200 and 325 mesh and containing 8 to 12% phosphorus is coated with nickel to form a composite-clad powder having a size between 140 and 270 mesh and containing 20 to 40% of the nickel phosphorus nucleus and 60 to 80% of the nickel coating.

The powder is sprayed in the identical manner described in Example 1. The coating obtained is mechanically bonded to the base and is slightly porous. This coating may be subsequently fused by a welding torch or furnace heated to form a homogenous pore-free coating welded to the base material.

EXAMPLE 6

A nickel-boron powder is coated with nickel to form a composite flame-spray

powder having a size between 120 and 325 mesh and containing 70 to 90% nickel, based on the nickel boron. The powder was sprayed in the manner described in Example 1 and a high quality of self-fluxing coating was formed.

The coating is mechanically bonded to the base and may be subsequently fused with a welding torch or in a furnace to form a dense homogenous, non-porous coating. When applied to a reactive base material, such as molybdenum, in a thickness of .006" to .010" or heavier, the coating can be fused to the base material by a torch or furnace without atmosphere control and below the recrystallization temperature of pure molybdenum, and will protect the molybdenum base from an oxidizing atmosphere at elevated temperatures up to the melting point of the nickel-boron coating.

EXAMPLE 7

Metallic cobalt is deposited as a coating on zirconia powder by the reduction of a cobalt ammonium sulphate solution with hydrogen so as to form a cobalt-clad zirconia flame-spray powder having a size between

140 mesh and 15 microns and containing 35 to 95% cobalt, based on the zirconia. The material is sprayed in the manner described in Example 1 on a grit-blasted base and a cermet coating is formed which shows excellent adhesion to the base and which will retard oxidation of the base. The coating furthermore has a high degree of hardness even at elevated temperatures, excellent shock-resistance and abrasion-resistance, and the metal matrix material is evenly distributed throughout the applied coating.

It is possible to vary the percentages of the ceramic in the composition between about 5 and 75% by weight in order to vary the properties of the coating. With an increased amount of ceramic in the cermet coating, the hardness and wear-resistant properties of the coating are correspondingly increased and the thermal conductivity decreased. Conversely, with an increasing amount of the cobalt matrix the bonding and shock-resistant properties are increased.

EXAMPLE 8

Al_2O_3 powder of a mesh size between 80 microns and 10 microns is coated with nickel in the manner described in Example 1 to produce a composite powder containing 25 to 95% of the nickel based on the aluminum oxide and having a particle size beteen 140 mesh and 15 microns. The powder is sprayed in the manner described in Example I on a grit-blasted base, and a cermet coating is formed which shows excellent adhesion to the base, a high degree of hardness even at elevated temperatures, and excellent thermal shock and abrasion-resistant characteristics. The metal matrix is evenly distributed throughout the sprayed conting.

In this case too it is possible to vary the percentage of the ceramic in the composite between 5 and 75% by weight, and with an increasing amount of ceramic, the hardness and wear-resistant properties increase, whereas with an increase of the nickel, the thermal conductivity, bonding and shock-resistant properties are increased.

EXAMPLE 9

Industrial diamond powder having a size between -120 and +140 mesh was coated with nickel in the manner described in Example 1 so that the nickel-clad composite powder formed contained about 25 to 50% by weight of the nickel, based on the diamonds. The powder was sprayed in the manner described in Example 1 on a steel base prepared by grit blasting, thus forming an excellent hone or lap in which the diamonds were firmly bonded in place.

EXAMPLE 10

Cobalt-bonded tungsten carbide particles of sharp, angular shape were coated with nickel in the manner described in Example 1 so as to produce a nickel-clad flame spray powder having a particle size between 100 and 325 mesh and containing 20 to 50% nickel based on the tungsten carbide. The powder was sprayed in the manner described in Example 9, with the formation of an excellent cutting hone or lap. The sharp angular edges of the initial tungsten carbide were retained in the coating.

Similar results were obtained when using

crystalline tungsten carbide in place of the cobalt bonded tungsten carbide particles.

EXAMPLE 11

A nucleus of elemental phosphorus powder was coated with nickel to form a nickel-clad flame spray powder having a particle size between 100 and 325 mesh and containing 80 to 93% nickel based on the phosphorus. The composite powder is sprayed with the flame spray gun described in Example 1 on a steel base prepared by lightly grit-blasting, using the spraying conditions as described in Example 1. During the spraying phosphorus combines with the nickel in an exothermic reaction, greatly enhancing the thermal efficiency of the spraying and producing an excellent coating which has self-fluxing properties.

EXAMPLE 12

A nickel boron powder is coated with copper and the copper-coated composite further coated with nickel to form a composite-clad flame spray powder having a particle size between 100 and 325 mesh containing 63 to 67% nickel and 26 to 32% copper and 2 to 10% boron by weight. The powder is sprayed in a powder-type flame spray gun on a lightly grit-blasted steel base with the flame spray gun

and method as described in Example 1. An excellent self-fluxing alloy is formed, which when fused in place by heating with an acetylene torch, forms a dense coating which corresponds in characteristics to monel.

EXAMPLE 13

A nickel boron powder is coated with chromium and the resulting coated powder in turn coated with nickel so as to form a flame spray composite-clad powder having a mesh size between 100 and 325 and containing 70 to 80% nickel and 18 to 20% chrome and 2 to 10% boron by weight. The powder is sprayed in the manner described in Example 12, resulting in a self-fluxing alloy coating which, when fused in place in the manner described in Example 12, produces a high grade coating having characteristics similar to nichrome V.

EXAMPLE 14

Nickel-bonded titanium carbide particles having a size between 140 and 325 mesh are coated with nickel, as described in Example 1, so as to produce a nickel-clad flame spray powder having a particle size between 100 and 270 mesh and containing 20 to 50% nickel based on the titanium carbide. The material

is sprayed in the manner described in Example 1 on a base with surface roughened by grit-blasting, and a high grade, bonded titanium carbide coating is formed in which the nickel acts as a matrix binding material.

When properly finished by grinding, the resultant coating is an excellent hard-facing, extremely resistant-to-wear coating even at elevated temperatures.

Similar results are obtained when using crystalline titanium carbide particles in place of the nickel-bonded titanium carbide particles.

EXAMPLE 15

Copper powder is coated with nickel in the manner described in Example 1 so as to form a nickel-clad composite flame spray powder having a particle size between 100 and 325 mesh and containing 50 to 70% nickel based on the copper. Upon spraying in the manner described in Example 1 on a base roughened by grit-blasting or other means, an excellent, corrosion and oxidation-resistant coating is formed. A similar coating is formed if the copper is replaced with chromium in an amount of 15 to 25% chromium based on the nickel.

EXAMPLE 16

Molybdenum disilicide powder is coated with nickel in the manner described in Example 1 so as to form a composite-clad flame spray powder having a particle size between 140 mesh and 10 microns, and containing 15 to 40% nickel by weight based on the disilicide. The powder is sprayed with the flame spray gun described in Example 1 on a base material roughened by grit-blasting.

The resultant oxidation-resistant coating is very dense, but may be further improved by subsequent heat treatment in a neutral to reducing atmosphere.

EXAMPLE 17

Example 10 is repeated except in place of the nickel, nickel phosphorus is used containing 4 to 12% of phosphorus. A similar coating resulted upon spraying, which however was self-fluxing.

EXAMPLE 18

Chromium boride powder is coated with nickel in the manner described in Example 1 so as to form a flame spray powder having a mesh size between 120 and 325 and containing 15 to 50% of nickel, based on the

chromium boride. Upon spraying in the manner described in Example 1, a boride coating of high quality is obtained which is resistant to wetting by molten metals.

EXAMPLE 19

Silver solder powder is coated with nickel in the manner described in Example 1 so as to produce a nickel-clad composite powder having a size between 120 and 325 mesh and containing 25 to 50% nickel based on the silver solder. Upon spraying in the manner described in Example 1 on a base material prepared by grit-blasting, a low-fusing temperature, self-fluxing coating is formed which, when subsequently fused, is a homogenous, pore-free coating securely fused to the base material.

A simple mixture of powders consisting of 20 to 65% of this nickel-coated silver solder and 35 to 85% of a carbide (Example 10) is sprayed in the manner described in Example 1. The resultant coating, when fused, consists of angular carbide particles securely bonded to each other and to the base material.

The fused coating may be suitably finished by grinding for use as a wear-resisting coating or used, as fused, where the coated article is

to be used as a hone or lap, the sharp edges of the carbide inclusions constituting the abrading or cutting edges.

EXAMPLE 20

Titanium is coated with nickel as described in Example 1 to produce a powder having a particle size between 100 and 325 mesh and containing 10 to 50% nickel based on the titanium.

The nickel protects the titanium from oxidation during storage and when spraying.

Upon spraying in the manner described in Example 1, on a base material prepared by grit-blasting, the nickel and titanium combine in the flame to form a corrosion-resistant coating.

EXAMPLE 21

A niobium powder is coated with nickel in the manner described in Example 1 so as to form a composite nickel-clad flame spray powder having a particle size between 100 and 325 mesh and containing 5 to 40% by weight of nickel based on the niobium.

The nickel protects the niobium from oxidation during storage and when spraying.

Upon spraying in the manner described in Example 1 on a base material prepared by grit-blasting, the nickel and niobium combine in the flame to form a corrosion-resistant material.

EXAMPLE 22

A molybdenum powder was coated with nickel in the manner described in Example 1 so as to produce a nickel-clad flame spray powder having a particle size between 100 and 325 mesh and containing 5 to 40% nickel based on the molybdenum.

The nickel protects the molybdenum from oxidation during storage and when spraying.

Upon spraying in the manner described in Example 1 on a base material prepared by grit-blasting, the nickel and molybdenum combine in the flame to form a corrosion-resistant material.

EXAMPLE 23

A titanium boride powder was coated with nickel so as to form a flame spray powder having a particle size between 100 and 325 mesh and containing 20 to 50% nickel based on the titanium boride.

The nickel protects the titanium boride during the spray.

Upon spraying in the manner described in Example 1, on a base material prepared by grit-blasting, a securely bonded nickel-titanium boride composite coating is achieved.

EXAMPLE 24

A silver powder is coated with nickel so as to form a nickel-clad flame spray powder having a particle size between 100 and 325 mesh and containing 30 to 70% nickel based on the silver.

Upon spraying in the manner described in Example 1, on a base material prepared by grit-blasting, the nickel and silver combine in the flame to produce a new material which is securely bonded to the base and is excellent for use as electrical contacts or the like.

During the spraying heat was evolved upon the combination of the nickel and silver, increasing the thermal economy of the process.

EXAMPLE 25

An aluminum powder is copper-plated so as to form a copper-clad flame spray powder having a particle size between 100 and 325 mesh and containing 85 to 98% or 8 to 20% copper based on the aluminum.

Upon spraying in the manner described in

Example 1, on a base material prepared by grit-blasting, the copper and aluminum combined in the flame to form a harder, corrosion-resistant alloy.

EXAMPLE 26

A silicon powder was coated with copper so as to form a copper-clad flame spray powder having a particle size between 100 and 325 mesh and containing 50 to 80% by weight of copper based on the silicon.

Upon spraying in the manner described in Example 1, on a base material prepared by grit-blasting, the copper and silicon combine in the flame to form coatings of a material considerably more inert than copper.

EXAMPLE 27

Tellurium powder was coated with copper so as to form a composite having a particle size between 100 and 325 mesh and containing 50 to 80% copper based on the tellurium.

Upon spraying in the manner described in Example 1, on a base material prepared by grit-blasting, the copper and tellurium combine to form a new material.

During the spraying heat was evolved

upon the combination of the copper and tellurium, increasing the thermal economy of the process.

EXAMPLE 28

Tin powder is coated with copper so as to form a copper-clad composite flame spray powder having a mesh size between 100 and 325 mesh and containing 75 to 95% copper based on the tin.

Upon spraying in the manner described in Example 1, upon a base material prepared by grit-blasting, the copper and tin combined in the flame to produce a ductile, corrosion-resistant coating.

EXAMPLE 29

Lead powder is coated with copper so as to form composite flame spray powder having a particle size between 100 and 325 mesh and containing 50 to 90% copper based on the lead.

Upon spraying in the manner described in Example 1, upon a base material prepared by grit-blasting, an excellent, leaded copper material is deposited which is suitable for use as a bearing.

EXAMPLE 30

The nickel-clad flame spray powder of Example 1 is mixed with about 20% by weight

of low pressure polyethylene powder and molded at a temperature of about 212° F. into the form of a rod of 1/8" diameter. The rod is sprayed, using a conventional wire-type flame spray gun sold by Metco Inc. of Westbury, Long Island, as the Metco-type 4E Gun. The spraying is effected with acetylene at a pressure of 15 p.s.i. and a flow rate of 37 cu.ft./hr. with oxygen as oxidizing gas at a pressure of 38 p.s.i. and a flow rate of 75 cu.ft./hr; with air as a blast gas at a pressure of 40 p.s.i. and a flow rate of 25 cu.ft./min. The end coating produced is similar to the coating produced in Example 1.

EXAMPLE 31

The nickel-clad flame spray powder of Example 10 is compacted and sintered in the form of a rod .125" in diameter. The rod is sprayed, using a conventional wire type flame spray gun sold by Metco Inc. as the Metco-type 4E Gun. The spraying is effected with acetylene at a pressure of 15 p.s.i. and a flow rate of 37 cu.ft./hr. with oxygen as the oxidizing gas at a pressure of 38 p.s.i. and a flow rate of 75 cu.ft./hr. Air is used as a blast gas at a pressure of 55 p.s.i. and a flow rate of 30 cu.ft./min. The end coating produced is similar to the coating produced in Example 10.

EXAMPLE 32

A wire is formed by encasing a core of aluminum in a tube of nickel and drawing to a size of .12[illegible] diameter plus or minus .002. The wire contains 82 to 84% by weight of nickel based on the aluminum.

The wire is sprayed, using a conventional wire type flame spray gun sold by Metco Inc. of Westbury, Long Island, as the Metco-type 4E Gun. Spraying is effected with acetylene at a pressure of 15 p.s.i. and a flow rate of 37 cu.ft./hr. with oxygen as the oxidizing gas at a pressure of 38 p.s.i. and a flow rate of 75 cu.ft./hr. Air is used as a blast gas at a pressure of 55 p.s.i. and a flow rate of 30 cu.ft./min. After initiation of the exothermic combination reaction at the melting wire tip, the flow of fuel and oxidizing gas may be drastically reduced, thus utilizing the heat of reaction to aid in melting the spray material and contributing to the over-all economy of the process. The end coating produced is similar to the coating produced in Example 1.

Similar results are also obtained using 55 - 90% by weight of nickel in the wire

EXAMPLE 33

A composite wire is formed by winding individual wires of nickel and aluminum and drawing the same to a thickness of .125" plus or minus .002". The wire contains 82 to 84% by weight of nickel based on the aluminum. The wire is sprayed in the manner described in Example 32, with identical conditions and coating results.

EXAMPLE 34

A self-fluxing silver-solder powder containing 15% silver, 5% phosphorus and 80% copper, is coated with copper so as to form a composite flame spray powder having a particle size between 100 and 325 mesh and containing 20 to 50% copper based on the silver-solder.

Upon spraying in the manner described in Example 1, on a base material prepared by light grit-blasting, an excellent, low melting point, self-fluxing alloy is deposited.

EXAMPLE 35

Example 34 is repeated except nickel is used in place of the copper. Similar results are obtained.

EXAMPLE 36

A simple mixture of powders containing 10 to 25% of the composite nickel - nickel phosphorus powder described in Example 5 and 75 to 90% of copper or copper alloy powder of the kind known as "Everdur" is sprayed with the gun and spray conditions described in Example 1.

The coating as described is mechanically bonded to the base material and slightly porous by nature. It may be subsequently fused by torch or furnace heating to form a homogeneous, pore-free coating welded to the base material. After fusion the coating is a fairly hard, corrosion-resistant, welded bronze overlay.

EXAMPLE 37

Example 36 is repeated, using, however, the composite nickel - phosphorus powder described in Example 11 in place of the nickel - nickel phosphorus powder.

Comparable results are obtained.

EXAMPLE 38

A simple mixture of powders containing 69% of the composite powder as described in Example 6 and 31% pure copper powder in the particle size range -140 and +325 mesh is sprayed with the gun as described in Example 1.

The coating as applied may be

subsequently fused without atmosphere control, to form a homogenous alloy fused to the base material, which corresponds in characteristics to monel.

EXAMPLE 39

A simple mixture of powders containing 81% of the composite powder as described in Example 6 and 19% of pure chromium powder in the particle size range -140 and +325 mesh is sprayed with the gun as described in Example 1.

The coating as applied may be subsequently fused without atmosphere control, to form a homogenous alloy fused to the base material, which corresponds in characteristics to Nichrome V.

EXAMPLE 40

Example 9 is repeated except in place of the nickel, nickel phosphorus was used containing 6 to 12% of phosphorus. A similar coating resulted upon spraying, which however was self-fluxing. Fusion bonding of particles to each other and to the base was accomplished by fusing the applied coating.

EXAMPLE 41

The coated diamond powder of Example 9 is mixed with nickel-coated silver solder powder

of Example 19 in the proportion of 50 to 75% diamond to 25 to 50% matrix material.

The mixture was sprayed in the manner described in Example 1 and the deposit subsequently fused.

The resultant coating was a dense, pore-free coating fused to the base material in which the diamonds were securely anchored by the low melting point, self-fluxing matrix metal.

EXAMPLE 42

Example 14 is repeated except in place of the nickel, nickel phosphorus is used containing 4 to 12% of phosphorus. A similar coating resulted which, however, was self-fluxing.

EXAMPLE 43

A silicon powder having a particle size between 140 and 325 mesh is coated with molybdenum in the known manner and a composite powder is formed containing about 35 to 39% by weight of silicon and about 61 to 65% by weight of molybdenum, and a size of 100 to 270 mesh.

The powder thus formed is flame-sprayed on a base material which has been prepared

by light grit-blasting, in the manner described in Example 1.

The molybdenum coating and the silicon base combine in the heat of the flame, forming a molybdenum silicon inter-metallic which deposits on the base as a dense, high quality coating which exhibits excellent resistance to oxidation at elevated temperatures and will protect the base material from oxidation.

EXAMPLE 44

A molybdenum powder having a particle size range between 140 and 325 mesh is coated with silicon in the known manner and a composite powder is formed containing about 35 to 39% by weight of silicon and about 61 to 65% by weight of molybdenum, and a size of 100 to 270 mesh.

The powder thus formed is flame-sprayed on a base material which has been prepared by light grit-blasting. The spraying is effected at about five inches from the plate, using a powder type plasma flame-spray gun sold by Metco Inc. of Westbury, Long Island, New York, under the trade name of Type MB Plasma Flame Gun. The spraying is effected at a rate of six to nine lbs. of powder per hour, using argon gas as the plasma gas at a pressure of 100 p.s.i. and a flow rate of 110 cu. ft./hr., using argon as the powder carrier gas at 100 p.s.i. and a flow rate of

11.5 cu. ft./hr., using a No. 3 (pointed) electrode and No. 3R Argon nozzle, and using arc current of 550 amperes at 45 volts.

The molybdenum base and silicon coating combine in the heat of the flame, forming a molybdenum silicon inter-metallic which deposits on the base as a dense, high quality coating which exhibits excellent resistance to oxidation at high temperatures and will protect the base material from oxidation.

EXAMPLE 45

A silicon powder having a particle size between 140 and 325 mesh is coated with chromium in the known manner, and a composite powder is formed containing about 48 to 85% chromium and 15 to 52% silicon by weight and a size of 100 to 270 mesh.

The powder thus formed is flame-sprayed on a base material which has been prepared by light grit-blasting in the manner described in Example 1.

The chromium coating and the silicon base combine in the heat of the flame, forming a chromium-silicon inter-metallic which deposits on the base as a dense, high quality coating which exhibits excellent resistance to oxidation at elevated temperatures and will protect the base material from oxidation.

EXAMPLE 46

A chromium powder having a particle size between 140 and 325 mesh is coated with silicon in the known manner, and a composite powder is formed containing about 48 to 85% chromium and 15 to 52% silicon by weight and a size of 100 to 270 mesh.

The powder thus formed is flame-sprayed on a base material which has been prepared by light grit-blasting. The spraying is effected at about five inches from the plate, using a powder type plasma flame-spray gun sold by Metco Inc. of Westbury, Long Island, New York, under the trade name of Type 7M5 Plasma Flame Gun. The spraying is effected at a rate of six to nine lbs. of powder per hour, using argon gas as the plasma gas at a pressure of 100 p.s.i. and a flow rate of 110 cu. ft./hr., using argon as the powder carrier gas at 100 p.s.i. and a flow rate of 11.5 cu. ft./hr., using a No. 3 (pointed) electrode and No. 3R Argon nozzle, and using arc current of 550 amperes at 45 volts.

The chromium base and silicon coating combine in the heat of the flame, forming a chromium silicon inter-metallic which deposits on the base as a dense, high quality coating which exhibits excellent resistance to oxidation at high temperatures and will protect the base material from oxidation.

EXAMPLE 47

A zirconium powder having a particle size between 140 and 325 mesh is coated with chromium in the known manner and a composite powder is formed containing about 47% zirconium and 53% chromium by weight and a size of 100 to 270 mesh.

The powder thus formed is flame-sprayed on a base material in the manner described in Example 1.

The chromium coating and the zirconium base combine in the heat of the flame, forming a chromium zirconium inter-metallic which deposits on the base as a dense, high quality coating which exhibits excellent resistance to oxidation at high temperatures.

EXAMPLE 48

A titanium powder having a particle size range between 140 and 325 mesh is coated with chromium in the known manner and a composite powder is formed containing about 35% chromium and 65% titanium by weight and a size of 100 to 270 mesh.

The powder thus formed is flame-sprayed on a base material which has been prepared by light grit-blasting in the manner described in Example 1.

The chromium coating and the titanium base combine in the heat of the flame, forming a chromium titanium inter-metallic which deposits on the base as a dense, high quality coating which exhibits excellent resistance to oxidation at high temperatures.

EXAMPLE 49

A titanium powder having a particle size range between 140 and 325 mesh is coated with silicon in the known manner and a composite powder is formed containing about 35 to 65% titanium and 35 to 65% silicon by weight and a size of 100 to 270 mesh.

The powder thus formed is flame-sprayed on a base material which has been prepared by light grit-blasting. The spraying is effected at about five inches from the plate, using a

powder type plasma flame-spray gun sold by Metco Inc. of Westbury, Long Island, New York, under the trade name of Type MB Plasma Flame Gun. The spraying is effected at a rate of six to nine lbs. of powder per hour, using argon gas as the plasma gas at a pressure of 100 p.s.i. and a flow rate of 110 cu. ft./hr., using argon as the powder carrier gas at 100 p.s.i. and a flow rate of 11.5 cu. ft/hr., using a No. 3 (pointed) electrode and No. 3R Argon nozzle, and using arc current of 550 amperes at 45 volts.

The titanium base and silicon coating combine in the heat of the flame, forming a titanium silicon inter-metallic which deposits on the base as a dense, high quality coating which exhibits excellent resistance to oxidation at high temperatures and will protect the base material from oxidation.

EXAMPLE 50

A dysprosium powder having a particle size between 140 and 325 mesh is coated with aluminum in the known manner and a composite powder is formed containing 60 to 75% dysprosium and 25 to 40% aluminum by weight and a size of 100 to 270 mesh.

The powder thus formed is flame-sprayed on a base material which has been prepared by light grit-blasting in the manner described in Example 1.

The aluminum coating and the dysprosium base combine in the heat of the flame with a strong exothermic action, forming a dysprosium aluminum inter-metallic compound which deposits on the base as a dense, high quality coating which exhibits excellent properties at high temperatures.

EXAMPLE 51

A lanthanum powder having a particle size between 140 and 325 mesh is coated with aluminum in the known manner and a composite powder is formed containing 70 to 75% lanthanum and 25 to 30% aluminum by weight and a size of 100 to 270 mesh.

The powder thus formed is flame-sprayed on a base material which has been prepared by grit-blasting in the manner described in Example 1.

The aluminum coating and the lanthanum base combine in the heat of the flame with a strong exothermic action, forming a lanthanum aluminum inter-metallic compound which deposits on the base as a dense, high quality coating which exhibits excellent properties at high temperatures.

EXAMPLE 52

A chromium powder having a particle size between 140 and 325 mesh is coated with aluminum in the known manner and a composite powder is formed consisting of 60 to 62% chromium and 38 to 40% aluminum by weight and a size of 100 to 270 mesh.

The powder thus formed is flame-sprayed on a base material which has been prepared by grit-blasting in the manner described in

Example 1.

The aluminum coating and the chromium base combine in the heat of the flame with a strong exothermic action, forming a chromium aluminum inter-metallic compound which deposits on the base as a dense, high quality coating of very high melting point and excellent oxidation-resistance.

EXAMPLE 53

Example 52 is repeated except that the composite powder is formed with an aluminum core and chromium coating. Identical results are obtained.

As may be noted from the foregoing the flame spraying of synergistically-acting composites in accordance with the invention is effected in the conventional manner, using the conventional flame spray equipment and utilizing conventional surface-preparation, though in certain instances wherein the spray coating has self-bonding characteristics, special surface-preparation other than a good cleaning, is not critical.

While the invention has been described in detail with reference to certain specific embodiments, various changes and modifications which fall within the spirit of the invention and scope of the appended claims will become apparent to the skilled artisan. The invention is therefore only intended to be

limited by, the appended claims or their equivalents wherein we have endeavored to claim all inherent novelty.

We claim:

1. In the flame spray process in which a heat-fusible material is heated in a heating zone to at least heat-softened condition and propelled in said condition out of said zone in finely divided form, the improvement which comprises passing the heat-fusible material into said zone in the form of individual, synergistically clad particles comprising a nucleus and at least one coating layer of a material differing from said nucleus and synergistically acting with the said nucleus in the process.

2. Improvement according to claim 1 in which said nucleus and said coating layer are of materials exothermically reacting with each other at the temperature developed in said heating zone.

3. Improvement according to claim 1 in which said coating layer comprises a bonding agent for said nucleus.

4. Improvement according to claim 1 in which said nucleus contains a self-fluxing material.

5. Improvement according to claim 1 in which said nucleus comprises a refractory material and in which said coating comprises a bonding matrix for said nucleus.

6. Improvement according to claim 1 in which said coating layer comprises nickel and in which said nucleus is a member selected from the group consisting of aluminum, nickel-phosphorus, nickel-boron, phosphorus-copper, chromium, silver solder, and silver.

7. Improvement according to claim 6 in which said coating material is nickel and in which said nucleus contains aluminum, said aluminum being present in amounts of about 10 to 45% based on the nickel.

8. Improvement according to claim 1 in which said coating layer is nickel and said nucleus a refractory material.

9. Improvement according to claim 1 in which said coating layer is nickel and said nucleus is a carbide.

10. Improvement according to claim 9 in which said carbide is tungsten carbide.

11. Improvement according to claim 1 in which said coating layer is nickel and in which said nucleus is aluminum oxide.

12. Improvement according to claim 1 in which said coating layer is nickel and said nucleus is diamond.

13. Improvement according to claim 1 in which said coating layer is nickel and said nucleus contains aluminum, and in which said synergistically clad particles are passed into said heating zone in admixture with a refractory oxide powder.

14. Improvement according to claim 13 in which said refractory oxide is aluminum oxide.

15. Improvement according to claim 1 in which said coating layer is cobalt and said nucleus is zirconia.

16. Improvement according to claim 1 in which said coating layer is copper and in which said nucleus comprises a member selected from the group consisting of tin, lead, and aluminum.

17. Improvement according to claim 1 in which one of said coating layer and said nucleus comprises silicon and the other a member selected from the group consisting of molybdenum, chromium, aluminum and titanium.

18. Improvement according to claim 1 in which one of said coating layer and said nucleus comprises chromium and the other a member selected from the group consisting of silicon, zirconium, titanium and aluminum.

19. Improvement according to claim 1 in which one of said coating layer and said nucleus comprises aluminum and the other a member selected from the group consisting of dysprosium, lanthanum and chromium.

20. In the flame spray process in which a heat-fusible material is heated in a heating zone to at least heat-softened condition and propelled in said condition out of said zone in finely divided form, the improvement which comprises passing the heat-fusible material into said zone in the form of a composite comprising at least two exothermically reacting components.

21. Improvement according to claim 20 in which said heat-fusible material is in the form of a wire.

22. Improvement according to claim 21 in which one component of said composite comprises nickel and the other aluminum.

23. Improvement according to claim 22 in which said wire has an aluminum core and nickel covering.

24. A flame spray powder in the form of individual, synergistically clad particles comprising a nucleus and at least one coating layer of a material differing from said nucleus and synergistically active with said nucleus in flame spraying.

25. A flame spray powder according to claim 24 in which said nucleus and said coating layer are of exothermically reacting materials.

26. A flame spray powder according to claim 24 in which said coating layer comprises a bonding agent for said nucleus.

27. A flame spray powder according to claim 24 in which said nucleus contains a self-fluxing material.

28. A flame spray powder according to claim 24 in which said nucleus comprises a refractory material and said coating comprises a bonding matrix for the material of said nucleus.

29. A flame spray powder according to claim 24 in which said coating layer comprises nickel and in which said nucleus is a member selected from the group consisting of aluminum, nickel-phosphorus, nickel-boron, phosphorus-copper, chromium, silver solder, and silver.

30. A flame spray powder according to claim 24 in which said coating material is nickel and in which said nucleus contains aluminum, said aluminum being present in amounts of about 10 to 45% based on the nickel.

31. A flame spray powder according to claim 24 in which said coating layer is nickel and said nucleus is a refractory material.

32. A flame spray powder according to claim 24 in which said coating layer is nickel and said nucleus is a carbide.

33. A flame spray powder according to claim 32 in which said carbide is tungsten carbide.

34. A flame spray powder according to claim 24 in which said coating layer is nickel and said nucleus is aluminum oxide.

35. A flame spray powder according to claim 24 in which said coating layer is nickel and said nucleus is diamond.

36. A flame spray powder according to claim 24 in which said coating layer is nickel and said nucleus contains aluminum, and in which said powder is in admixture with a refractory oxide powder.

37. A flame spray powder according to claim 24 in which said refractory oxide powder is aluminum oxide powder.

38. A flame spray powder according to claim 24 in which said coating layer is cobalt and said nucleus is zirconia.

39. A flame spray powder according to claim 24 in which said coating layer is copper and said nucleus comprises a member selected from the group consisting of tin, lead and aluminum.

40. A flame spray powder according to claim 24 in which said powder is bonded in the form of a wire.

41. A flame spray powder according to claim 24 in which one of said coating layer and said nucleus comprises silicon and the other a member selected from the group consisting of molybdenum, chromium, aluminum and titanium.

42. A flame spray powder according to claim 24 in which one of said coating layer and said nucleus comprises chromium and the other a member selected from the group consisting of silicon, zirconium, titanium and aluminum.

43. A flame spray powder according to claim 24 in which one of said coating layer and said nucleus comprises aluminum and the other a member selected from the group consisting of dysprosium, lanthanum and chromium.

44. A flame spray powder according to claim 24 including at least one additional coating layer differing from said nucleus and first mentioned coating layer and synergistically active with at least one of said nucleus and first mentioned coating layer in flame spraying.

45. A flame spray material in the form of a composite comprising at least two exothermically reacting components in intimate contact with each other.

46. A flame spray wire containing at least two exothermically reacting components in intimate contact with each other.

47. A flame spray wire according to claim 46 in which one of said components comprises nickel and the other aluminum.

48. A flame spray wire according to claim 47 in which said wire has an aluminum core and nickel covering.

49. In the flame spray process in which a heat-fusible material is heated in a heating zone to at least heat-softened condition and propelled in said condition out of said zone in finely divided form, the improvement which comprises passing the heat-fusible material into said zone in the form of individual, synergistically clad particles comprising a nucleus and at least two coating layers of materials differing from each other and synergistically acting with each other in the process.

50. A flame spray powder in the form of individual, synergistically clad particles comprising a nucleus and at least two separate coating layers of material differing from each other and synergistically active with each other in flame spraying.

51. In the flame spraying process in which a heat-fusible material is sprayed onto a base, the improvement to increase the bond which comprises spraying an intermediate layer of two components exothermically reacting with each other, forming an inter-metallic compound.

52. Improvement according to claim 51 in which one of said components comprises nickel and the other aluminum.

53. Improvement according to claim 51 in which one of said components comprises chromium and the other aluminum.

54. A base having a flame spray coating bonded in place by an intermediate bonding layer of an inter-metallic compound formed from two exothermically reacting components.

55. An article according to claim 54 in which said inter-metallic compound is a nickel aluminum inter-metallic compound.

56. An article according to claim 54 in which said inter-metallic compound is a chromium aluminum inter-metallic compound.

57. A base having a flame sprayed coating of an inter-metallic compound formed of two exothermically reacting components.

58. A coated base according to claim 57 in which said inter-metallic compound is a nickel aluminum inter-metallic compound.

59. A coated base according to claim 57 in which said inter-metallic compound is a chromium aluminum inter-metallic compound.

60. A base having a flame sprayed coating produced by the process according to claim 1.

61. A base having a flame sprayed coating produced by the process according to claim 49.

62. Improvement according to claim 6 in which said coating material is nickel and in which said nucleus contains aluminum, said aluminum being present in amounts of about 16 to 18% based on the nickel.

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Ser. No. 305

JOINT INVENTORS

Oath, Power of Attorney, and Petition

Being duly sworn, we, FERDINAND J. DITTRICH and ARTHUR P. SHEPARD, depose and say that we are respectively citizens of United States of America residing respectively at 2457 New Place, Bellmore, Long Island, New York, and 29-01 - 159th Street, Flushing, New York City,

that we have read the foregoing specification and claims and we verily believe we are the original, first, and joint inventors of the invention or discovery in Flame Spraying Synergistic Composites

described and claimed therein; that we do not know and do not believe that this invention was ever known or used before our invention or discovery thereof, or patented or described in any printed publication in any country before our invention or discovery thereof, or more than one year prior to this application, or in public use or on sale in the United States for more than one year prior to this application; that this invention or discovery has not been patented in any country foreign to the United States on an application filed by us or our legal representatives or assigns more than twelve months before this application; and that no application for patent on this invention or discovery has been filed by us or our representatives or assigns in any country foreign to the United States.

And we hereby appoint

BURGESS, DINKLAGE & SPRUNG (Reg. No. 15,379), a firm composed of Ralph D. Dinklage and Arnold Sprung of 233 Broadway, New York 7, N. Y.

our attorneys with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent Office connected therewith.

Wherefore we pray that Letters Patent be granted to us for the invention or discovery described and claimed in the foregoing specification and claims, and we hereby subscribe our names to the foregoing specification and claims, oath, power of attorney, and this petition, this 15th day of November, 19 60.

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State of NEW YORK
County of NASSAU } ss

Before me personally appeared FERDINAND J. DITTRICH and ARTHUR P. SHEPARD, to me known to be the persons described in the above application for patent, who signed the foregoing instrument in my presence, and made oath before me to the allegations set forth therein as being under oath, on the day and year aforesaid.

SEAL

JOHN J. DONOVAN
Notary Public, State of New York
No. 30 6012703
Qualified in Nassau County
Commission Expires March 30, 1961

John J. Donovan
Notary Public

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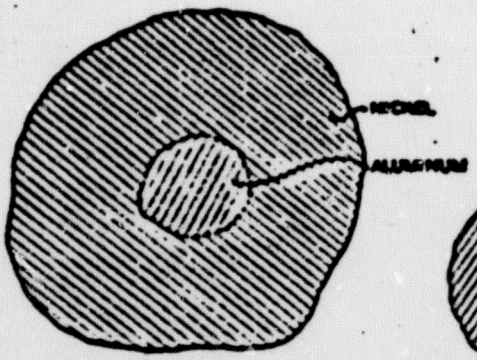

Fig. 1

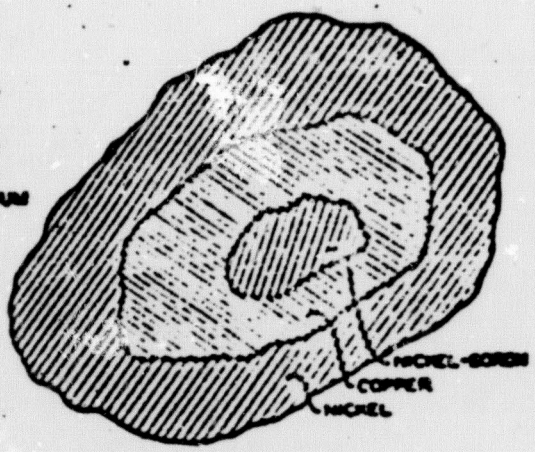

Fig. 2

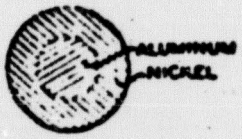

Fig. 3

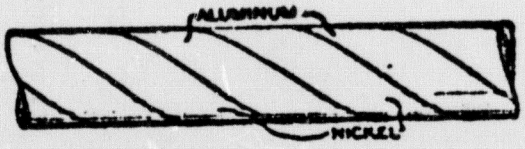

Fig. 4

INVENTORS
FERDINAND J. DITTRICH
ARTHUR R. SHEPARD
BY
Burgess Dinklage & Sprung
ATTORNEYS

55

E 234

U. S. DEPARTMENT OF COMMERCE
PATENT OFFICE
WASHINGTON

Form No. 3

Burgess, Dinklage & Sprung
233 Broadway
New York 7, N. Y.

Applicant: Ferdinand J. Dittrich et al.
Ser. No. 72,543
Filed Nov. 22, 1960
For FLAME SPRAYING SYNERGISTIC COMPOSITIES

MAILED
AUG 16 1961
PAT. OFF. 25

Please find below a communication from the EXAMINER in charge of this application.

Commissioner of Patents.

This application has been examined.

Patents cited to show classification:

I.	Alexander	1,971,804	Apr. 28, 1934	117/46
	Wasserman	2,288,869	July 7, 1942	117/46
II.	Robinson	2,612,581	Sept. 30, 1952	29/191
	Homer	2,933,415	Apr. 19, 1961	29/191

This application is found to contain claims drawn to two separate and distinct inventions. Restriction as indicated below is required under Rule 142.

I. Claims 1 to 23, 49, and 51-62 are drawn to a flame spray coating process and the product of said process would be classified in class 117, subclass 46 with the Alexander and Wasserman patents.

II. Claims 24-48 and 50 are drawn to a powder and wire comprising composite metal stock and would be classified in class 29, subclass 191 with the Robinson and Homer patents.

The two inventions are distinct because the powder and wire in the claims of Group II have other utility than in the flame spraying process defined in the claims of Group I. For example, the metal powder in the claims of Group II could be

merely dusted on a metal base and thereafter heated to bond the coating to the metal base. The metal wire of the claims of Group II could be merely laid upon the metal base and heated to melt the wire and bond the melted coating to the metal base.

Since these distinct inventions have acquired a separate status in the art by the issuance of patents to each individual patentee as shown by the above cited exemplary art, restriction for examination purposes is proper.

Applicants are advised that their response to be complete must include a provisional election of one of the above inventions identified as I or II, (See Rule 143) even though they traverse the requirement.

Summary:

Claims subject to restriction: 1-62.

Claims rejected: None.

Claims allowed: None.

K.C. Wheeless/kjc

Examiner

E 236

MAIL ROOM
AUG
16
1951
U.S. PATENT OFFICE

BURGESS, DINKLAGE & SPRUNG
Attorneys
[illegible] BROADWAY
NEW YORK 7, N. Y.

#4

Date: August 13, 1951

Hon. Commissioner of Patents
Washington 25, D. C.

ON ALL PAPERS PLEASE
FURNISH OUR FILE NO.
Heteo 305.1

Dear Sir:

Re the application of Ferdinand J. Dietrich and Arthur F. Shepard

for FLAME SPRAYING SYNERGISTIC CUTOSINES

we enclose

(x) Specification

(x) Oath, Power of Attorney and Petition

( ) 1 Sheet(s) Drawings

x(x) 47 Claim(s) in excess of 20

(x) $ 77.00 filing fee (covered by enclosed check)

( ) Assignment

( ) $3.00 recording fee (covered by enclosed check)

( ) Priority is hereby claimed on the basis of the following:

Country	Serial No.	Date

Kindly transfer the drawings from application Serial No. 72 543, of Nov.22,1[illegible] to the instant application.

Respectfully,

BURGESS, DINKLAGE & SPRUNG

By [signature]

58

ATTORNEY'S ROOM
JUN 27 1956
U. S. PATENT OFFICE

E 237

#5

Access to application Serial No. 772,543 filed Nov. 12, 1958 is requested. The subject application is cited in patent 3,254,570.

The patent is a continuation in part of the subject application

Fidelman & Wolff

M. Fidelman

APPROVED
JUN 27 1956
T. L. Gilreath
ATTORNEY'S ROOM

59

R

ER

E 238

#6

RICHARD R. MYBECK
LAWYER
PATENT ATTORNEY

383-1244
Area Code 312

200 SOUTH ELMWOOD AVENUE
OAK PARK, ILLINOIS

MAIL ROOM
FEB 21 1968
U.S. PATENT OFFICE

REQUEST FOR ACCESS

February 19, 1968

Commissioner of Patents
Washington, D.C. 20231

Sir:

In connection with my accompanying order for File Wrapper and Contents, please grant me access to the file of Abandoned U.S. Patent Application Serial No. 72,543 filed November 22, 1960 and referred to in issued U. S. Patent No. 3,322,515.

Respectfully,

Richard R. Mybeck
Richard R. Mybeck

RRM:bc
Encl.

APPROVED

MAR 7 1968

DOCUMENT SERVICES BRANCH

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E 239 #7

MAY 2 2 1968

April 22, 1968

Hon. Commissioner of Patents

Washington, D. C. 20231

S I R :

PETITION FOR ACCESS

The undersigned hereby petitions for access to the file of abandoned application Serial No. 72,543, filed November 22, 1960.

This application is mentioned in patent 3,322,515, issued May 30, 1967.

Access to this file is necessary in order to determine the scope and validity of the claims of the issued patent.

Respectfully,

SHOEMAKER AND MATTARE

By John F. Smith

Approved
5/23/68
L. R. Plummer

61 R

Form PO-436
(1-1-58)

E 240

72543
SERIAL NO. (Series of 1960)

Assistant examiner

Division No.
25

Applicant(s)

U.S. PATENT OFFICE
JAN 19 1961
DIV. 25

SEARCHED

Class	Sub	Date	Ex'r
117	105	8-4-61	KRW
	46	8-4-61	
	23	8-7-61	
29	191	Cancelled	
	191.2		
	194		

INDEX OF CLAIMS

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SYMBOLS	STATUS
✓	Rejected
=	Allowed
– (Through movement)	Cancelled
+	Restriction requirement
N	Nonelected invention or species
I	Interference
A	Appeal

16-76250-6

67

72543

E 241

CONTENTS

1. Application ___ papers.
2. PRINT Jan. 12, 1961
3. Restriction AUG 16 1961
4. Transfer of Docs. Aug. 16, 1961
5. 6-27-66
6. REQUEST FOR ACCESS FEB 24, 1968
7. Request for Access Apr 22, 1968
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16—11910-7 U. S. GOVERNMENT PRINTING OFFICE

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